HERTZBERG – NEW METHOD, INC. EAST VANDALIA ROAD, JACKSONVILLE, ILL. 62650

TITLE NO.	ACCOUNT NO.	LOT AND TICKET NO.

DP-4

CLOTH COLOR

HEIGHT

CHARGING INFORMATION				HEIGHT	PICA	WRAP
STUBBING		FRONT COVER				
HAND SEW		NO TRIM				
THRU SEW		PAGES LAMINATED				
THRU SEW ON TAPE		EXTRA THICKNESS				
HAND ADHESIVE		MAP POCKET PAPER				
LENGTHWISE		MAP POCKET CLOTH		SPECIAL WORK AND PREP.		
FOREIGN TITLE		SPECIAL WORK				
LINES OF LETTERING						

TITLE NUMBER

SHIPMENT NO.

NEW TITLE

THIRD PANEL

FOURTH PANEL

CALL NUMBER

CHANGE CALL NO.

ADD'N. TO CALL NO.

NO TRIM

MAP POCKET

COLOR NUMBER

2. INSERT IN THE VOLUME

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

COLLISION OF READING COMPANY COMMUTER TRAIN AND TRACTOR-SEMITRAILER

NEAR YARDLEY, PENNSYLVANIA

JUNE 5, 1975

REPORT NUMBER: NTSB-RAR-76-4

UNITED STATES GOVERNMENT

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5. Report Date
March 3, 1976

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Washington, D.C. 20594

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NATIONAL TRANSPORTATION SAFETY BOARD
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Railroad Accident Report
June 5, 1975

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

About 11:06 p.m. on June 5, 1975, a Reading Company commuter train struck a tractor-semitrailer (truck) at a grade crossing near Yardley, Pennsylvania. The truck was transporting three coils of steel, two of which penetrated the first commuter car. The three occupants of the lead car were killed and an occupant of the second car was injured slightly. The truckdriver was uninjured. The semitrailer was torn from the tractor and damaged beyond repair and the lead commuter car was damaged extensively.

At the time of the collision, the automatic grade crossing signal system was functioning. The truckdriver said he had not seen or heard the warning signals.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the truckdriver to stop the truck in accordance with the warning signals.

17. Key Words

Commuter train; tractor-semitrailer; steel coil; penetration; grade crossing; signal system; crossing protection; sight distance; visibility; weather.

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FOREWORD

The accident described in this report was investigated under the authority of the Independent Safety Board Act of 1974. The report is based on facts from an investigation conducted by the National Transportation Safety Board in cooperation with the Federal Railroad Administration, Pennsylvania Public Utility Commission, the Lower Makefield Township Police, the Reading Company, the General Electric Company, the Evans Transportation Company, and the United States Steel Corporation.

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File No. SS-R-38

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: March 3, 1976

COLLISION OF READING COMPANY COMMUTER TRAIN AND TRACTOR-SEMITRAILER, NEAR YARDLEY, PENNSYLVANIA JUNE 5, 1975

SYNOPSIS

About 11:06 p.m. on June 5, 1975, a Reading Company commuter train struck a tractor-semitrailer (truck) at a grade crossing near Yardley, Pennsylvania. The truck was transporting three coils of steel, two of which penetrated the first commuter car. The three occupants of the lead car were killed and an occupant of the second car was injured slightly. The truckdriver was uninjured. The semitrailer was torn from the tractor and damaged beyond repair and the lead commuter car was damaged extensively.

At the time of the collision, the automatic grade crossing signal system was functioning. The truckdriver said he had not seen or heard the warning signals.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the truckdriver to stop the truck in accordance with the warning signals.

FACTS

The Accident

On June 5, 1975, Reading Company commuter train 571 was traveling westbound en route from Trenton, New Jersey, to Philadelphia, Pennsylvania, on the New York Branch of the Reading Company. The train consisted of two cars, No. 9024 and No. 9023. The train was traveling at an estimated speed of 60 mph toward the Stony Hill Road grade crossing near Yardley, Pennsylvania.

The engineer was at the forward control station of the lead car, No. 9024. His view forward through the front window at the control station was obscured by the configuration of the control station, the curvature of the track, and the adverse weather conditions. A trainman and one passenger were seated, facing forward, on the right side of the lead car, one on the aisle and one next to the window. The conductor was riding in the front of the passenger section on No. 9023.

As the train was approaching the grade crossing from the east at about 11:05 p.m., a tractor-semitrailer (truck) was approaching the crossing from the south. The truck was occupied only by the driver and was carrying three coils of steel, individually secured to the trailer bed by chains. Two of the coils weighed 8 tons and one coil weighed 5 tons.

Three hundred feet south of the crossing, the truckdriver's view of the grade crossing and of the crossing's warning signals was obscured by the structure of the tractor and the adverse weather conditions.

The truckdriver stated that he had downshifted and was traveling about 15 mph as he approached the grade crossing. He neither saw flashing lights nor heard any bells or train whistle, so he proceeded to cross the tracks. His first indication that a train was coming was when he saw its headlights illuminate the tractor's cab. He attempted to accelerate to clear the tracks, but he was not able to do so before the train struck the trailer. The collision occurred at 11:06 p.m., based on the time at which the engineer's watch had stopped.

The lead car's buffer sill struck the right rear of the trailer. The protruding car coupler penetrated the trailer's main-frame rail 8 feet from the rear of the trailer, about 3 feet above ground level. The fifth-wheel assembly was torn free of the tractor and the trailer was rotated clockwise and westward down the track. The coils of steel were torn from the chains which had secured them to the trailer. The two coils on the rear of the trailer entered the lead rail car. The 8-ton coil on the front of the trailer dropped onto the pavement north of the tracks.

The body of the engineer was found on the floor in the aisle to the rear of the 5-ton coil, about 22 feet from the control station. The trainman and the passenger were found pinned in their seats by the collapsed vestibule partitions. The center vestibule compartment had been dislodged rearward 26 feet, to the vicinity of the 23rd row of seats, by the 8-ton coil.

The conductor, who had been riding in the front of the second car, was thrown from his seat upon impact and was injured slightly. The truckdriver was uninjured.

The train stopped 1,155 feet west of the crossing.

Accident Site

The Railroad -- The New York Branch of the Reading Company consists of double tracks that run southwest and northeast between Trenton, New Jersey, and Philadelphia, Pennsylvania. The railroad right-of-way is 150 feet wide west of the centerline of Stony Hill Road and 200 feet wide east of the centerline.

The track is straight from 11,000 feet east of the crossing to a 540-foot, 1-degree curve to the left, 942 feet east of the crossing. The track is straight for the final 402 feet. The tracks have a 0.36-percent upgrade approaching the crossing from the east.

Two automatic back-to-back flashers with crossbucks are located within the railroad right-of-way, one in the southeast guadrant of the crossing and the other in the northwest quadrant. Both of these flashers faced north and south along Stony Hill Road. The flasher in the northwest quadrant is also equipped with a bell and with an additional flasher, which faces a service road that enters Stony Hill Road on the north side of the tracks. All the warning signals are activated by westbound trains when they reach a point 5,170 feet east of the crossing's centerline. The duration of the visual and audible signals is dependent upon the speed of each individual train; the faster the speed of the train, the shorter the warning time before the train reaches the crossing. At 60 mph, train 571 would have provided just less than 1 minute of warning to drivers approaching the grade crossing from either direction on Stony Hill Road.

A whistle board was located 1,331 feet east of the crossing. A speed board, indicating a 60-mph speed zone, was located 750 feet east of the crossing. (See Figure 1 for the location of railroad devices and other physical objects along the track.)

The Highway -- Stony Hill Road is a 20-foot-wide, asphalt-paved, two-lane, north-south, winding country road maintained by the Commonwealth of Pennsylvania. The two lanes are separated by solid double yellow lines. There is a 4-inch-wide, solid white line on the outer edges of the pavement. The posted legal speed is 45 mph. (See Figures 1 and 2.)

Five hundred and eighty-five feet south of the grade crossing, northbound motor vehicle traffic crosses a short, narrow bridge, after which the roadway returns to a 20-foot width. About 400 feet south of the crossing, the road begins a 4-percent upgrade and at 350 feet, the road begins a 3-degree curve to the right. It continues on that grade and curve to within 50 feet of the crossing, where the grade decreases to about 1.5 percent and the road straightens. The road crosses the railroad tracks at an 85-degree angle.

A sign to give motorists advance warning of the railroad crossing is located on the right side of the roadway, about 460 feet south of the crossing. The sign is obscured partially to motorists approaching from the south by bushes and tree branches.

The automatic railroad flasher signal and crossbuck, located on the left side of Stony Hill Road, are visible to motorists approaching from the south about 500 feet from the crossing. The automatic flasher and crossbuck, located on the right side of the crossing, are visible from the south about 300 feet from the crossing.

Figure 1. Plan of Stony Hill rail/highway grade crossing.

Figure 2. Stony Hill grade crossing from direction of truck.

Motorists and traincrews who had traversed the grade crossing earlier in the evening stated the automatic warning signal had been functioning.

A traffic survey on Stony Hill Road in the vicinity of the crossing was conducted in 1973. The average daily traffic volume for northbound and southbound traffic was 2,420 vehicles. Two weeks after the accident, a 24-hour survey yielded the following count:

Tractor-semitrailers	131
Trucks	191
Pickups	204
Cars	2,080
Misc.	39
Total	2,648
Trains	38

From January 1, 1974, through June 6, 1975, there were four accidents, including this collision, at the Stony Hill Road grade crossing. These accidents resulted in four fatalities, nine injuries, and property damage estimated at $420,000.

The Stony Hill Road grade crossing had been assigned a hazard-rating index number of .041. 1/ A hazard-rating index number of .041 means that no additional protection is currently warranted.

Environmental Factors -- On the night of the accident, a thunderstorm was in progress. It was raining hard. There was no artificial lighting along this section of Stony Hill Road.

As the driver approached the crossing from the south, the driver's view east along the tracks was obscured by trees, bushes, a hedge, and a residence up to a point 110 feet south of the nearest rail. For the next 80 feet, his view east was obscured intermittently by bushes and trees. He did not have an unobstructed view to the east until 30 feet south of the nearest rail. At that point, the truckdriver could have seen about 250 feet east along the track. His view to the west was obstructed almost totally until he was about 25 feet south of the nearest rail.

The Train

Train 571 consisted of two electrically driven, stainless steel commuter cars, equipped with electric-pneumatic and dynamic brakes. The

1/ The Federal Aid Safer Roads Demonstration Program, Section 230 of the Highway Act of 1973.

cars had seats for 129 passengers. Two fixed, sealed-beam, white headlights were mounted above the front vestibule door. There was no speed-recording device on the train.

The cars were manufactured by the General Electric Company in 1971 to specifications which required that they withstand an 800,000-pound static compression end load at the centerline of the draft gear. The cars were equipped with collision posts. Each car was 85 feet long and weighed about 127,000 pounds. They were propelled by alternating-current traction motors that were powered through an overhead catenary system. Train movement was controlled by an automatic signal system, acted upon by the engineer.

The Reading Company maintenance records for cars No. 9023 and 9024 revealed that the required monthly inspections had been performed in May 1975; the required biennial inspections had been performed on No. 9023 in June 1974 and on No. 9024 in May 1975. No discrepancies were noted in these records for either car.

The conductor stated that in preparation for the trip to Philadelphia, the engineer had changed ends and the engineer and the brakeman had tested the brakes properly before the train departed from Trenton at 10:54 p.m. on June 5, 1975. The conductor noted nothing unusual about the train at that time.

The Truck

The tractor-semitrailer was owned and operated by Donald C. Metzger of Warrington, Pennsylvania. It was leased to David Graham Company of Kearny, New Jersey, which leased it to Evans Transportation Company of Levittown, Pennsylvania, under the provisions of Federal Motor Carrier Safety Regulations. The gross weight of the truck and cargo was calculated to have been 71,930 pounds. The legal gross weight permitted by Commonwealth of Pennsylvania law is 73,000 pounds.

The Tractor -- The tractor was a 1968 Kenworth, Chassis No. 111259, conventional three-axle tractor with a sleeper box. It was equipped with a diesel engine, a four-speed main transmission and a four-speed auxiliary transmission, air brakes, and a Fontaine sliding fifth-wheel assembly. The tractor was not equipped with a tachograph. The tractor weighed about 17,000 pounds. It had been inspected on April 2, 1975, in compliance with the motor vehicle laws of the Commonwealth of Pennsylvania.

The Trailer -- The semitrailer was a 1971 Brown flatbed, Model 40P1-H2S, Serial No. M712355. It was manufactured by Clark Equipment Company and was equipped with a sliding tandem axle suspension. The

trailer had been inspected on May 14, 1975, in compliance with the motor vehicle laws of the Commonwealth of Pennsylvania.

The physical characteristics of the trailer were as follows:

Empty weight	11,290 pounds
Trailer length	40 feet
Trailer height (top of bed)	54 3/8 inches
Trailer width	96 inches

The Cargo -- The cargo consisted of three coils of steel, weighing 16,500 pounds (35 1/8 inches high by 48 3/4 inches in diameter), 16,060 pounds (35 1/8 inches high by 47 3/4 inches in diameter), and 10,480 pounds (35 1/8 inches high by 40 inches in diameter). Each coil was on a pallet (56 inches by 56 inches by 7 inches) which weighed about 200 pounds. The gross cargo load was 43,640 pounds. The three coils had been loaded on the trailer by United States Steel Corporation (U.S. Steel) employees, under the direction of the truckdriver.

The driver secured the palletized coils individually to the trailer bed with chains and chain binders and covered the coils with tarpaulins, which were secured. (See Figure 3.) Upon departure from U.S. Steel at 10:50 p.m., June 5, 1975, the load was inspected at the gate by company personnel for compliance with U.S. Steel loading requirements.

The Traincrew

The traincrew consisted of an engineer, a brakeman, and a conductor. They were qualified in their respective positions in accordance with Reading Company rules and were in compliance with requirements of the Federal Railroad Administration's hours-of-service regulation.

The Truckdriver

The truckdriver, 24 years old, was self-employed and had leased his truck and services to drive for David Graham Company in August 1974. He had been employed as a commercial driver for 2 years. At the time of the collision, he held a valid Commonwealth of Pennsylvania motor vehicle operator's license which authorized him to operate the type of equipment involved in the collision. He was certified as medically qualified to drive in interstate and intrastate commerce. The truckdriver was familiar with Stony Hill Road, and he frequently had used the route that he used on the day of the accident.

The Commonwealth of Pennsylvania's Bureau of Traffic Safety records revealed two tractor-trailer accidents and a traffic violation.

Damage

The Train -- The 8-ton coil of steel on the rear of the trailer struck the left front collision post of the lead car 38 inches above the

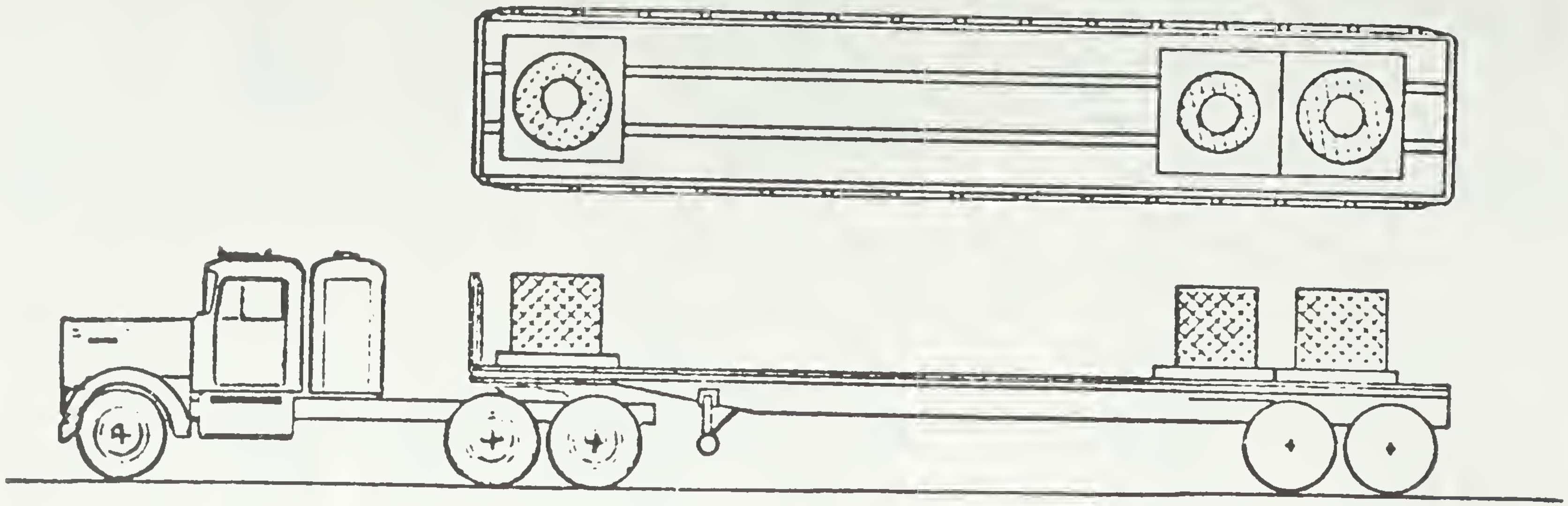


Figure 3. Plan view and profile of truck and cargo, representing typical loading method.

car floor, shearing the post at its base. The coil entered the front of the car, passed through the control vestibule, dislodged the front passenger compartment bulkhead, and entered the passenger compartment, damaging seats along the front left side of the car. Across the aisle, it dislodged seats and deformed the car wall along the front right side of the car. It struck the center vestibule partition, collapsed it upon the trainman and passenger, and continued into the rear passenger compartment, where it came to rest in the 22nd row of seats, 66 feet from the front of the car.

The 5-ton coil entered the front of the car just to the right of the first coil's point of entry. The second coil dislodged seats along the right front side of the car, crossed the aisle, and came to rest in the ninth row of seats, about 22 feet from the front of the car. (See Figures 4, 5, and 6.)

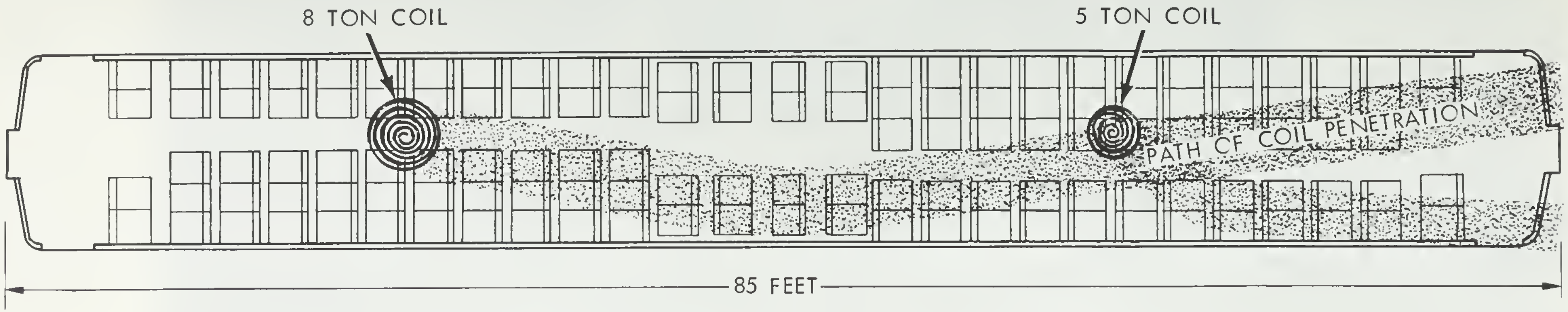
Exterior car components on the right side, to the rear of the center vestibule and below the floor line, were damaged slightly.

The Truck -- The trailer was torn loose from the tractor at the fifth-wheel assembly with only minor damage to the tractor because the fifth wheel separated from the tractor chassis. The trailer was rotated clockwise westward along the track, striking and dislodging the automatic warning signal on the north side of the track. As the trailer rotated off the track and away from the train, it contacted the right side of the train. The trailer came to rest 58 feet west of the crossing, facing the southeast, its left rear corner resting against a catenary pole and its right front corner resting on the ground just clear of the track ballast. The trailer's tandem axle suspension came to rest about 25 feet north of the catenary pole. (See Figure 7.)

The rear third of the right side of the trailer was deformed inward about 14 inches. The trailer frame was twisted badly. Its left rear and right front corners were damaged extensively. The trailer's sliding tandem axle suspension was disengaged from the trailer.

A round puncture, 3 inches in diameter, was found in the trailer's main frame rail on the right side, 8 feet from the rear. This puncture corresponded to the commuter car's protruding coupler horn.

The Signal Equipment -- The automatic warning signal in the northwest quadrant of the grade crossing was struck by the trailer, torn from its base, and damaged extensively as the signal and the trailer were carried westward by the train. The junction box, telegraph relay case, battery well, and a junction box attached to the catenary pole were damaged from impact with the dislodged warning signal and with debris from the trailer.



PLAN VIEW
SEPTA -READING SINGLE COMMUTER CAR AND COIL PENETRATION

Figure 4.

Figure 4. Plan view - Reading Company commuter car and coil penetration.

Figure 5. Interior of railcar 9024 after 8-ton coil penetration.

Figure 6. External view of 9024.

Figure 7. The trailer against catenary pole and highway signal mast

Tests

After the accident, investigators equipped a truck and a train similar in design and load to the accident vehicles.

The train and the truck were moved to their preimpact positions. Investigators recorded visibility and sight distances. Photos then were taken at 1-second intervals from the truckdriver's position, assuming a 15-mph approach to the crossing. Photos also were taken at 1-second intervals from the engineer's position, assuming a 60-mph approach of the train. (See Figure 8.)

The truck and the train made test approaches to the grade crossing. A full-service brake application, utilizing air and dynamic braking, was initiated on the train 100 feet before the crossing when it was moving at 57 mph. The train stopped 1,053 feet beyond the center of the crossing. Therefore, the total stopping distance of the test train is about 1,150 feet.

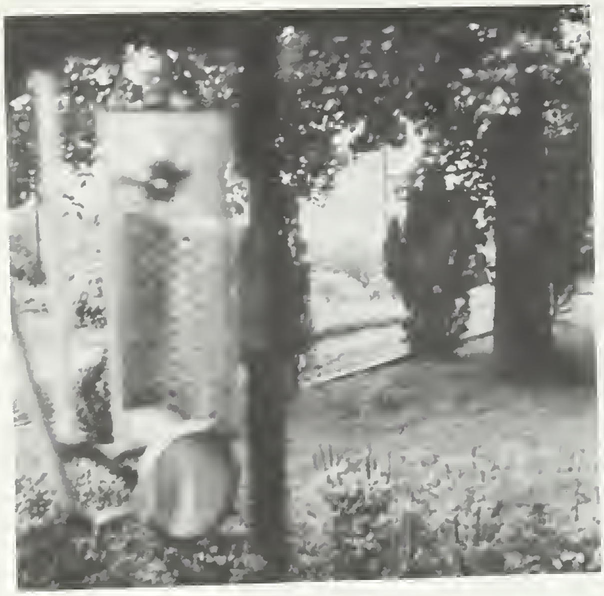
The circuitry of the signal system was tested shortly after the accident by the Federal Railroad Administration (FRA) and by Reading Company signalmen. Except for the flasher damaged in the collision, the system operated as designed. This included the standby battery supply that assures operation if line power is interrupted.

Safety Board investigators examined the damaged flasher and bell and made continuity tests of the damaged wiring and the signaling system. Except for crash damage, they noted no defects. Lamp bulbs were removed from the signaling assembly and examined. The examination disclosed that all of the bulbs were operable except one, which had a broken filament. When the investigators examined the broken filament under a miscroscope, they found that it had failed while it was lit.

ANALYSIS

The train had been operated in compliance with all applicable Reading Company operating rules and the truck met the Federal Bureau of Motor Carrier Safety requirements and the Commonwealth of Pennsylvania requirements. The steel coils were secured on the truck in accordance with motor carrier safety regulations; however, the crash loads in this accident were far greater than those anticipated by the regulations.

The driver testified that "there was absolutely no warning lights whatsoever" and that he did not hear the warning bell or other noise, nor did he see any lights. However, the postaccident inspection of the warning signal system, the laboratory inspection of the bulbs, and the observations of the signals by motorists and railroad employees before and after the collision confirm that the warning devices were indicating the approach of the train.



1

2

3

4

Figure 8. Driver's view of approaching train at selected intervals.

Under Pennsylvania law, a driver must stop when a grade crossing warning signal indicates the approach of a train. However, drivers often do not comply with this law. In this case, the closing speeds of the two vehicles indicate that if the truck had been stopped in compliance with the flashing signal, the train would have passed before the truck could have been started again.

The driver had used this route frequently. Although he may have had an illusion of good track visibility to the east, the vegetation along the right-of-way intermittently obscured the driver's view until the truck was near the track. The vehicle speeds, the darkness, and the adverse weather could have accounted for the driver's failure to see a train approaching from the east.

If a driver assumed he could see the track to the east, and if he did not see a train in that direction, he would have concentrated on the west side, which was more obstructed. The truckdriver probably did not stop because he did not see a train and he did not see the warning device or hear the warning bell or other noise.

This hypothesis suggests that the driver did not stop because he believed the risk of accident was not great. He may have been influenced by environmental factors. His partial view down the track may have increased the likelihood of an accident because it encouraged him to act on the basis of information which was inadequate to make a safe decision.

The large number of passengers at risk in rapid transit trains and commuter trains makes the need for effective grade crossing warning systems evident. Each year, 213 million passengers -- 93 percent of the total rail passenger volume -- are transported by commuter trains which use only 3,070 miles of track, or about 1 percent of the track in the United States. Even the low probability of accidents at grade crossings is unacceptable. If this train had been fully loaded, the number of fatalities would have been large.

It is not feasible to design commuter trains to protect passengers against forces such as those experienced by the train in this accident. Therefore, in order to protect the large number of commuter passengers, grade crossings along commuter and rapid rail routes must be improved.

The Safety Board noted in June 1971 in its "Special Study of Rapid Rail Transit Safety" 2/ that "Grade crossings are not compatible with rail rapid transit operation." The Safety Board is aware of the Department of Transportation's work in grade crossing safety. It notes, however, that there is no program directed specifically at the improvement of grade crossings used by rail commuters. Although commuter trains use only a small

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2/ National Transportation Safety Board, "Special Study of Rapid Rail Transit Safety," June 16, 1971. NTSB-RSS-71-1.

percentage of the total grade crossings, those crossings are the ones at which the largest number of passengers are at risk. Those crossings deserve the highest priority for improvement.

CONCLUSIONS

1. The train was operated in accordance with the operating procedures of the Reading Company.

2. The truck met the Federal Bureau of Motor Carrier Safety's requirements and the Commonwealth of Pennsylvania's requirements concerning satisfactory operating condition.

3. The steel coils were secured on the truck in accordance with motor carrier safety regulations; however, the crash loads in this accident were far greater than those intended by the regulations.

4. The warning device was indicating the approach of the train and was visible to the truckdriver as the truck approached the crossing.

5. The truckdriver did not stop before he entered the crossing.

6. If the driver had stopped in compliance with the flashing lights, the collision would not have occurred.

7. The evidence did not indicate why the driver failed to stop.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the truckdriver to stop the truck in accordance with warning signals.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board made two recommendations to the Department of Transportation. (See the Appendix.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

March 3, 1976

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX

ISSUED:

Forwarded to:

Honorable William T. Coleman, Jr.
Secretary
Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-76-13 and R-76-14

About 11:06 p.m. on June 5, 1975, a Reading Company commuter train struck a tractor-semitrailer (truck) at a grade crossing near Yardley, Pennsylvania. The truck was transporting three coils of steel, two of which penetrated the first commuter car. The three occupants of the lead car were killed and an occupant of the second car was injured slightly. The truckdriver was uninjured. The semi-trailer was torn from the tractor and damaged beyond repair and the lead commuter car was damaged extensively.

At the time of the collision, the automatic grade crossing signal system was functioning. The truckdriver said he had not seen or heard the warning signals.

Collisions between commuter trains and highway vehicles that can produce many fatalities can be expected wherever the transportation modes intersect at grade crossings. The Safety Board examined this type of collision in its investigation of a 1966 accident at Everett, Massachusetts, 1/ involving a collision of a commuter train with a fuel oil truck, and in a special study 2/ relating to rail rapid transit safety. In the accident report the Safety Board pointed out the incompatibility of commuter rail and highway traffic,

1/ National Transportation Safety Board, "Railroad-Highway Accident Report--Boston and Maine Corporation, Signal Diesel-Powered Passenger Car 563, Collision with Oxbow Transportation Company Tank Truck at Second Street Railroad/Highway Grade Crossing, Everett, Massachusetts, December 28, 1966." February 29, 1968.

2/ National Transportation Safety Board, "Special Study of Rapid Rail Transit Safety," June 16, 1971. NTSB-RSS-71-1.

and in its special study, the Board recommended eliminating grade crossings on commuter systems. In the accident that occurred at Yardley, three persons in the lead car were killed. If the train had contained more occupants, the loss of life would have been much greater. The potential for catastrophic loss in this class of accident is apparent.

The Safety Board is aware of the Department of Transportation's work in grade crossing safety. However, there is no program directed specifically at the improvement of grade crossings used by rail commuter traffic. Rail commuters use only 3,070 miles of track--1.5 percent of the total rail track; however, they represent 93 percent of the rail passengers. The small percentage of the total railroad-highway grade crossings at which the largest number of rail passengers is at risk deserves high priority for improvement.

Therefore, the National Transportation Safety Board recommends that the Department of Transportation:

1. Require flashing lights and gates as minimum protection at all grade crossings used by commuter trains. (R-76-13) (Class II, Priority Followup)

2. Develop a program directed at the improvement of all grade crossings used by commuter trains. This program should contemplate the separation of grades of all these crossings in the foreseeable future. (R-76-14)(Class III, Longer-Term Followup)

TODD, Chairman, McADAMS, THAYER, BURGESS and HALEY, Members, concurred in the above recommendations.

By: Webster B. Todd, Jr.
Chairman

700

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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

PENN CENTRAL TRANSPORTATION COMPANY

TRAIN COLLISIONS

LEETONIA, OHIO

JUNE 6, 1975

REPORT NUMBER: NTSB-RAR-76-2

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

About 11:00 p.m. on June 6, 1975, three freight trains of the Penn Central Transportation Company (PC) were involved in a collision near Leetonia, Ohio. Extra 6330 West collided with the rear of standing Extra 2278 West. Immediately thereafter, Extra 6259 East, which was on an adjacent track, struck the wrecked cars from the other two trains. One employee was killed and seven others were injured. Property damage amounted to about $1.25 million.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer and brakeman to assure the operation of the train at a speed slow enough to stop it within the visibility range. This violated the restricted speed rule required by the signal indication.

Recommendations were made concerning operating rules and the use of radios.

17. Key Words Rear end collision; stop-and-proceed signal; restricted speed; rapid; stalled; unit shutdown; grade signal; ascending grade; rock cut; block station; markers.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.	
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FOREWORD

This report is based upon an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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File No. SS-R-39

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: February 17, 1976

PENN CENTRAL TRANSPORTATION COMPANY TRAIN COLLISIONS LEETONIA, OHIO JUNE 6, 1975

SYNOPSIS

About 11:00 p.m. on June 6, 1975, three freight trains of the Penn Central Transportation Company (PC) were involved in a collision near Leetonia, Ohio. Extra 6330 West collided with the rear of standing Extra 2278 West. Immediately thereafter, Extra 6259 East, which was on an adjacent track, struck the wrecked cars from the other two trains. One employee was killed and seven others were injured. Property damage amounted to about $1.25 million.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer and brakeman to assure the operation of the train at a speed slow enough to stop it within the visibility range. This violated the restricted speed rule required by the signal indication.

FACTS

The Accident

On June 6, 1975, Extra 2278 West of the Penn Central Transportation Company (PC) was in the vicinity of Leetonia, Ohio. The train consisted of locomotive units 2278 and 3060, 17 loaded cars, and 42 empty cars. Extra 2278 West had a full crew including a fireman. Unit 2278 had a radio, but it was malfunctioning and it could receive only. The caboose had no radio, but it was equipped with operable flashing red markers displayed to the rear. The train passed Leetonia block station on No. 2 track west at 10:43 p.m. (See Figure 1.) When the train started up the grade west of Leetonia, it lost speed rapidly until it stalled. The caboose stopped 1,728 feet west of signal 653. The crew discovered that unit 3060 was not operating because the engine coolant was so low that it had actuated the low water and governor buttons, which had shut down the engine. Attempts to restart the unit were unsuccessful.

Extra 6330 West of the PC was on No. 2 track east of Leetonia, where it was waiting for Extra 2278 West to pass. It consisted of

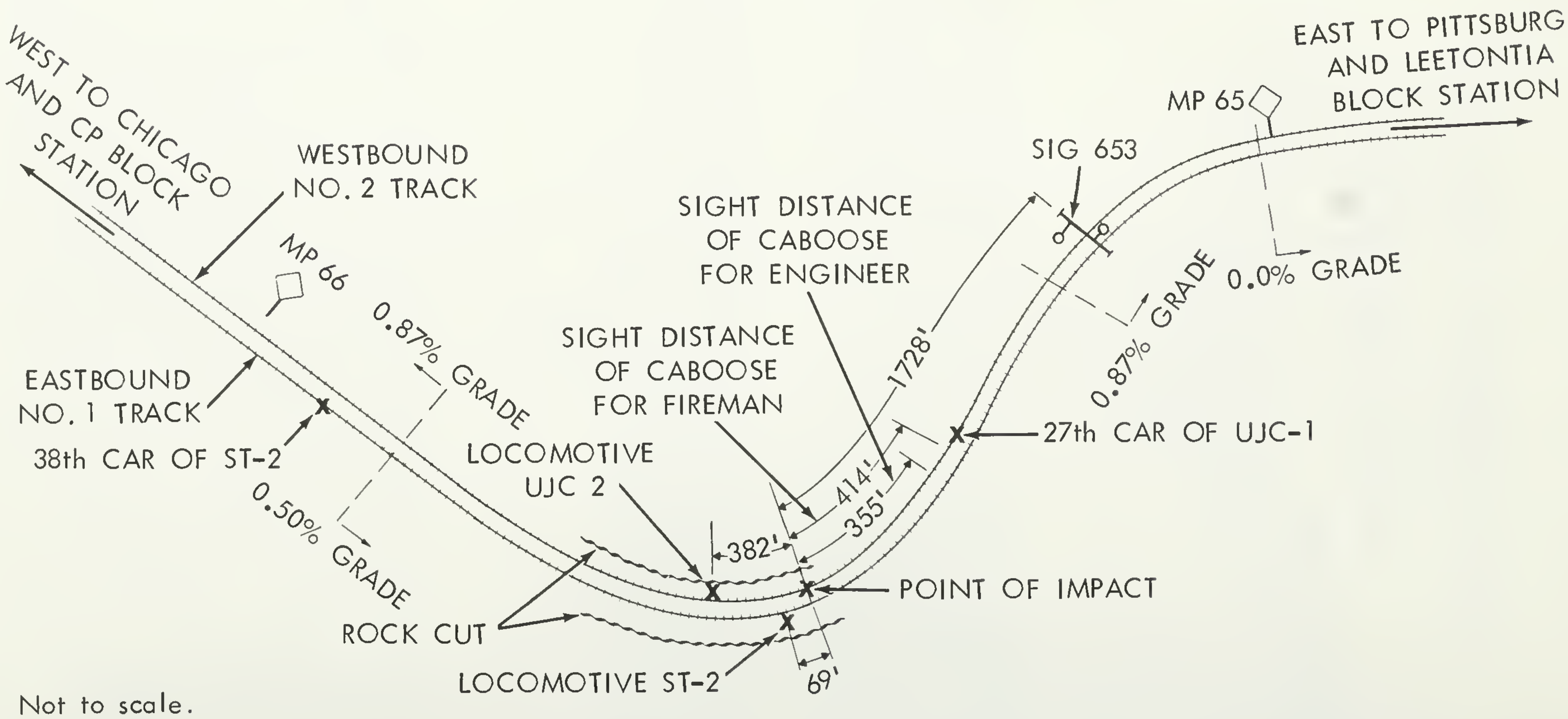

Figure 1. Pertinent points in connection with the accident involving Penn Central Transportation Company's Extra 6330 West, Extra 2278 West, and Extra 6259 East near Leetonia, Ohio, June 6, 1975.

locomotive units 6330, 6336, 6321, and 3020, 100 loaded cars, and 4 empty cars, including the caboose. Extra 6330 West had a full crew including a fireman. Both unit 6330 and the caboose were equipped with an operable radio.

Extra 6259 East of the PC was approaching Leetonia on the eastbound track (No. 1) adjacent to No. 2 track. Extra 6259 consisted of locomotive units 6259, 6072, and 6054, 60 loaded cars, and 5 empty cars. Unit 6259 had an operable radio, but there was no radio on the caboose.

After Extra 2278 West had cleared the interlocking at Leetonia block station, the block operator cleared the interlocking home signal for Extra 6330 West to follow Extra 2278 West on No. 2 track. Extra 6330 West moved to the interlocking home signal, where it stopped to comply with the "stop-and-proceed" signal indication. Before the fireman could restart the train, the signal indication changed to "approach." The train proceeded past Leetonia block station at 10:56 p.m.

The speed of the train was increased to about 25 mph between Leetonia and signal 653, the first automatic signal west of Leetonia interlocking. The surviving engine crewmen said that as signal 653 came into view, the signal displayed a proper "stop-and-proceed" indication. They called out the signal in accordance with rule 34.

The conductor and engineer gave conflicting statements as to whether Extra 6330 West stopped at signal 653. The engineer stated that he advised the fireman, who was operating the locomotive, to make a heavy brake application of about 30 pounds of air and to keep the train stretched. The engineer said that the fireman stopped the train for 2 to 3 minutes. The conductor stated that the train did not stop after leaving Leetonia block station until the emergency stop.

As Extra 6330 West moved past signal 653, the engineer said he cautioned the fireman to be alert because of the sharp curve ahead. The engineer got out of his seat on the fireman's side and stood at the front door, peering ahead. Suddenly, he saw the caboose and markers of Extra 2278 West on the track ahead. He also saw two white lights moving off the caboose toward the south. He called an alarm to his crew, told them to hit the floor, and told the fireman to apply the brakes in emergency. The engineer and the brakeman estimated the train's speed at 7 mph at this point. The engineer and head brakeman could not state positively whether the fireman applied the brakes in emergency.

The locomotive of Extra 6330 West struck the caboose of Extra 2278 West and forced it and the rear cars southward until they blocked No. 1 eastbound track. Extra 6330 West's locomotive units derailed northward, but they continued moving westward for about 380 feet between Extra 2278 West's train and the rock wall by the track.

About the time Extra 6330 West struck the rear of Extra 2278 West, Extra 6259 East entered the west end of the cut in which the accident occurred. The engineer had no advance warning of the situation ahead.

Extra 6259 East struck the cars of Extra 2278 West which were fouling No. 1 track. The estimated speed of Extra 6259 East at the time of impact was 28 to 30 mph. The locomotive units of Extra 6259 East derailed to the south against the south wall of the rock cut. Unit 6259 came to rest 69 feet west of the point of impact.

Postaccident Activities

After the accident, the conductor of Extra 2278 West went eastward to get help; he met the conductor of Extra 6330 West, who was heading to the front of his train and who had a portable radio. The conductor of Extra 2278 West used that radio to report the accident to Leetonia block station. The conductor of Extra 6330 West already had reported that his train was in emergency.

Rescue and emergency units from a number of area fire departments and rescue squads responded to the call for help. Railroad personnel assisted in freeing the injured, who were moved to a hospital.

The Accident Site and Method of Operation

The accident site is about 2.5 miles west of Leetonia block station and the town of Leetonia, Ohio. (See Figures 2 and 3.) The accident occurred in a rock cut which is on a 0.50-percent ascending grade westward, in a 4°5' curve to the right. There are two adjacent tracks, one eastbound and one westbound. The point of impact was 1,728 feet west of signal 653. At this point the tracks run through a cut. The walls of the cut are sheer rock. The inside (north) wall of the cut is about 35 to 40 feet high at the point of impact. The clearance between the rock wall and the north rail of the No. 2 track westbound is 6 to 8 feet.

The south wall of the cut is lower and farther from the eastbound track than the north wall is from the westbound track. There are 20 feet of clearance between the south rail of the eastbound track and the south wall of the cut. The distance between the track centers through the rock cut and accident site is 26 feet 6 inches.

At the time of the accident it was dark and clear and weather visibility was unlimited.

The accident occurred on the Valley Division of the PC. The Valley Division is equipped with automatic block signals; operation is governed by signal indications, timetable, train orders, general notices, and bulletins. There are no cab signals, speed controls, or other safety equipment in use except the deadman control on the locomotive.

Figure 2. View of the accident site as seen from the west.

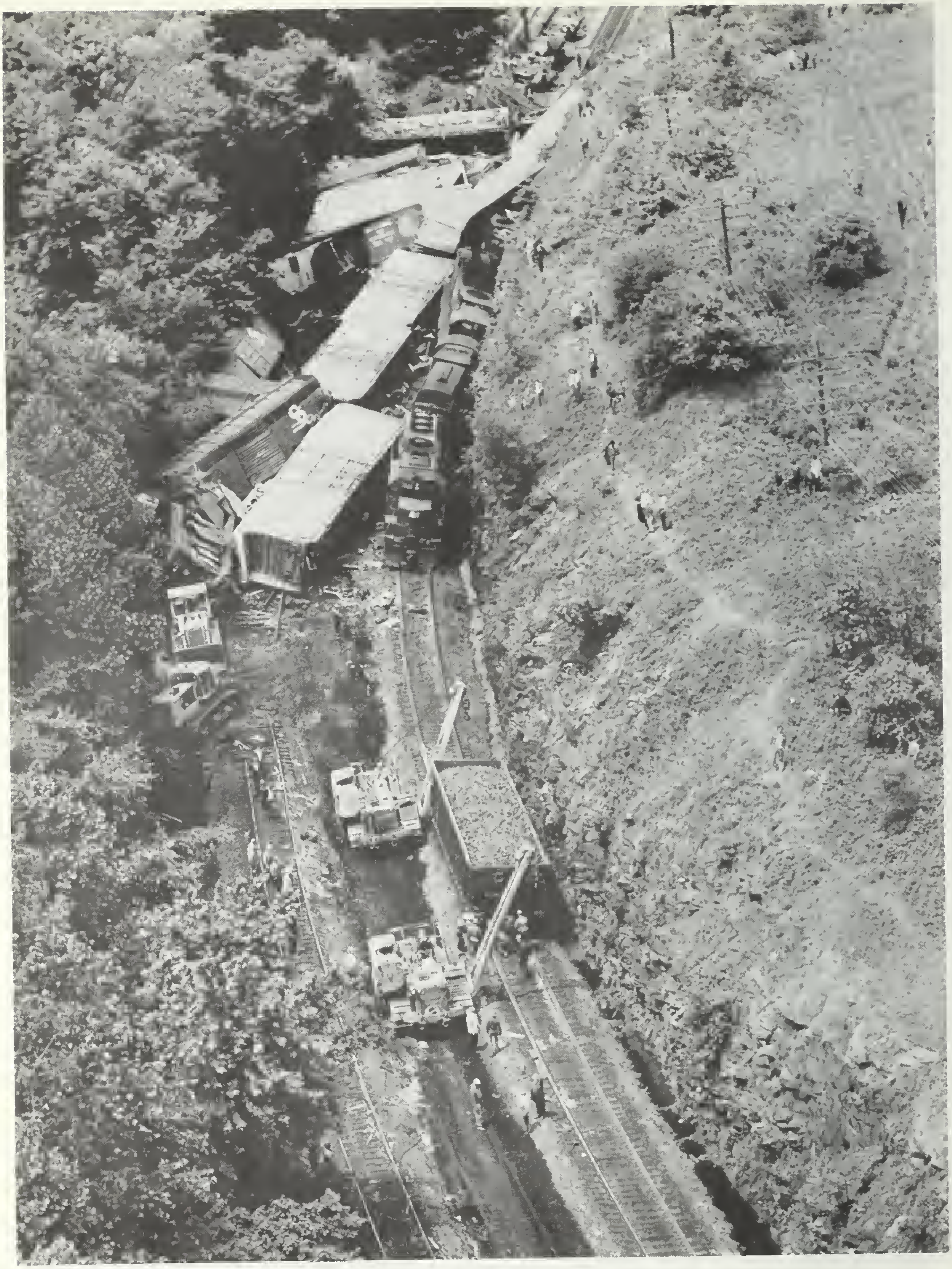

Figure 3. View of the accident site as seen from the east. The point of impact is off the bottom of the photograph.

Leetonia block station is located at milepost 63.2, east of the accident site, and CP block station is located at milepost 82.8, west of the accident site. The operators at these block stations report the passing of trains to each other and to the dispatcher.

Radio -- Most trains operating on the Valley Division are equipped with radios by which employees can communicate between the locomotive and the caboose, with another train, with the block operators, and with mobile stations. The dispatcher does not have a radio at his position, but he has access to one. However, some trains have no radio and some have radios only on the locomotive or caboose. Portable radios are assigned to conductors when possible. Employees in stations along the route are not advised whether a train is equipped with an operable radio.

History of train movements -- For the period of May 6, 1975, through June 6, 1975, records indicate that six trains stalled near mileposts 66 and 67. At least three of these involved motor failure. During that period, there were 670 trains operated westbound and 657 trains operated eastbound through this area.

Operating rules -- Operating rules governing employees are set forth in PC's "Rules for Conducting Transportation." Rules involved in this accident are Rule 251, Rule 291, Rule 400 N-3, Rule 34, and Rule 99. (See Appendix B.)

Rule 251 governs the movement of trains running in the same direction. The rule states that these trains will be governed by block signals, "whose indications will supersede the superiority of trains."

Rule 291 governs the use of the "stop-and-proceed" signal indication. The "stop-and-proceed" indication means that an engineer is to stop his train and then proceed at restricted speed. Restricted speed is defined: "...Proceed prepared to stop short of train, obstruction, or switch not properly lined looking out for broken rail, not exceeding 15 miles per hours."

Rule 400 N-3 governs the action of the engineer. It states that the engineer is responsible for the proper operation of the engine and for the conduct of other employees on the engine. The engineer must not allow any member of the crew to operate the engine except under his personal supervision.

Rule 34 states that all members of the crew must communicate a signal indication to one another as soon as it becomes clearly visible. If a train is not operated in accordance with the signal indication, the members of the crew must communicate this to the crewmember controlling the train, and they must stop the train if necessary.

Rule 99 relieves the flagman of the responsibility to flag in territory governed by automatic block signals. Therefore, the crew of Extra 2278 West was not required to flag against Extra 6330 West when Extra 2278 West stalled in the block of signal 653. Since Extra 2278 West was not stopped by an emergency brake application, there was no requirement to flag the adjacent track.

Property Damage

Cars 52 through 59, which included the caboose, were derailed from Extra 2278 West. The four locomotive units, cars 4 through 9, and car 27 were derailed from Extra 6330 West. The three locomotive units, cars 4 through 29, and car 38 were derailed from Extra 6259 East.

The locomotive cabs of unit 6330 on Extra 6330 West and unit 6259 on Extra 6259 East were crushed by the forces of the impact and by cars jamming them against the walls of the cut. The cabs were not sheared from the frames of the locomotives, and all of the crewmen who remained in the cabs survived.

Twenty-two cars and one locomotive unit were demolished. (See Figure 4.) Damage to equipment and facilities and the costs associated with clearing the wreckage were estimated to be $1.25 million, which is broken down as follows:

Locomotives	$ 825,000
Car Equipment	283,000
Tracks	6,600
Signals	1,000
Lading	30,600
Clearing Wreck	105,964
Total	$1,252,164

Medical and Pathological Information

The fireman of Extra 6330 West was killed. The engineer's pelvis was fractured and his hip dislocated. The head brakeman suffered head, face, and chin lacerations and a loosened tooth.

The right foot of the engineer of Extra 6259 East was fractured and he sustained severe lacerations. The head brakeman was scalded by boiler water and suffered fractured vertebrae, internal injuries, and lacerations. The flagman and conductor reported bruised knees.

The flagman of Extra 2278 West suffered a lumbosacral strain which he believed occurred as he was climbing the bank to avoid the wreckage.

Figure 4. General view of accident, showing locomotive of Extra 6330 West and cars of Extra 2278 West. View is toward the east.

Blood tests for alcohol, performed on the engineer and head brakeman of Extra 6330 West, were negative. No autopsy or blood alcohol tests were performed on the fireman.

(For information on the crew's qualifications, see Appendix A.)

Crashworthiness of Cabs

The crashworthiness of locomotive cabs has been addressed in other Safety Board accidents. 1/ The FRA has conducted some crash tests at the DOT test center, Pueblo, Colorado, with such things as refuge shelter and structural changes in mind. Thus far, changes have been suggested in the design of collision posts and certain deflection devices. Suggested changes in about 16 items have been made and became a part of the AAR Manual of Standards and Recommended Practices as of January 1, 1976. They include such things as shielded hinges, recessed water coolers and refrigerators, recessed radio sets, etc.

However, there is still an urgent need for continuing work in the crashworthiness of locomotive cabs. A better or different design may have reduced or eliminated the injuries in this accident.

Tests and Research

The tests performed on the signal system after the accident indicated that the system was functioning normally. The only discrepancies found in the system were that the bulb in the marker light unit of Signal 653 was missing and that the left horizontal bulb was misaligned in the socket, probably because someone had tampered with it. Also, the side doors to the light units had been removed on one or two units, probably by vandals.

Train Tests -- Several tests were conducted after the accident to determine Extra 6330 West's stopping distances, its sight distances both to signal 653 and to the rear of Extra 2278 West, and its minimum possible speed. (See Table No. 1 for the results of the visibility tests. Also, see Figure 5.)

1/ "Railroad Accident Report -- Burlington Northern Inc. Derailment of Extra 5701 East, at Sheridan, Wyoming, March 28, 1971," NTSB-RAR-72-4. "Railroad/Highway Accident Report -- Illinois Central Railroad Company Train No. 1, Collision with Gasoline Tank Truck at South Second Street Grade Crossing, Loda, Illinois, January 24, 1970," NTSB-RHR-71-1. "Railroad Accident Report -- Illinois Central Railroad Company, and Indiana Harbor Belt Railroad Company, Collision Between Yard Trains at Riverdale, Illinois, on September 8, 1970," NTSB-RAR-71-3.

TABLE NO. 1

TEST	SIGHT OBJECT	SIGNAL ASPECT	LIGHT CONDITIONS	SIGHT DISTANCE FROM ENGINEER'S SIDE-FEET	SIGHT DISTANCE FROM FIREMAN'S SIDE-FEET
Caboose Visibility	Simulated Caboose	N/A -	Daylight	355	414
Signal Visibility	Signal 653	Clear	Daylight	1155	1115
Signal Visibility	Signal 653	Clear	Night	1161	1136
Signal Visibility	Signal 653	Stop and proceed	Daylight	1147	1143
Signal Visibility	Signal 653	Stop and proceed	Night	1188	1146

Figure 5. Fireman's view from the approaching locomotive to the point of impact. Men standing in the foreground represent the position of the caboose of Extra 2278 West.

The train used for the stopping tests was similar in consist to Extra 6330 West. The test train consisted of units 6312, 6309, 6341, and 3009, 100 loaded cars, and no empty cars. The tests showed that at 10 mph, Extra 6330 West could have been stopped 59 feet before impact with the caboose. At 17 mph, the test train passed the location of the caboose by 326 feet. These tests indicate that Extra 6330 West was moving faster than the 7 mph estimated by the engineer and brakeman. It was not possible to determine the actual speed of the train.

Stopping tests were made with the automatic brake only. Table No. 2 shows the differences in equipment characteristics between the actual train and the test train:

TABLE NO. 2

	Extra 6330 West	Test Train
ABD Brakes	98	84
AB Brakes	6	17
Composition Shoes	78	62
Iron Shoes	26	39
Roller Bearings	98	86
Friction Bearings	6	15

A mathematical simulation of stopping distances showed that a train similar to Extra 6330 West, with a brake pipe pressure of 95 psi, should have stopped in 271 feet from a speed of 15 mph. The simulated tests did not allow for reaction time, curvature, or grade, and the stops were made by an emergency brake application.

To determine the minimum speed at which Extra 6330 West could have moved, a train with a consist similar to Extra 6330 West was used. After a stop at signal 653, the train proceeded westward to the point of impact at 1.92 mph without stalling.

Air brake tests, inspection of the undamaged portion of Extra 6330 West, and inspection of those facilities of the locomotive that could be tested did not reveal any fault that would have caused a brake failure. No brake tests were performed on the undamaged portions of Extra 2278 West or Extra 6259 East.

An inspection showed that the radio on Extra 2278 West had a blown power fuse to the transmitter. At the time of the depositions, no cause had been found for the failure of Extra 2278 West's locomotive unit 3060. At Conway Yard, Pa., where Extra 6278 West was inspected last, inspectors found that unit 3060 had a leak in the No. 14 water jumper, but they did not think that it was the cause of the loss of water which caused the shutdown.

Because of the damage and the severity of impact, the Safety Board does not believe that the positions of the locomotives' controls after the collision necessarily indicate their positions approaching the point of impact.

ANALYSIS

Operating Rules

The accident occurred because the crew of Extra 6330 West did not comply with Rules 291, 400 N-3, and 34. According to Rule 291, the crew was required to stop the train and then proceed at restricted speed. According to Rule 400 N-3, the engineer was responsible for the actions of all employeees on the engine. When the fireman of Extra 6330 West operated the train too fast for the "stop and proceed" indication, Rule 34 required the engineer and the brakeman to take preventive action.

If the crewmembers on the locomotive of Extra 6330 West had complied with the operating rules, the collision would have been avoided. When the fireman operated Extra 6330 West into the occupied block at such a speed that he could not stop the train short of Extra 2278 West, he violated Rule 291, which governs the "stop-and-proceed" signal. Even though the crew may have interpreted the signal to be a grade signal rather than a "stop-and-proceed" signal, the requirement to proceed at restricted speed still applied.

The engineer, who was responsible for the safe operation of the train and was the most experienced employee on the locomotive, failed to assure that the fireman operated the locomotive at a speed slow enough to stop short of a train ahead.

The responsibility for observing speed requirements is assigned primarily to the engineer; however, other members of the crew are required to take action if the engineer fails to comply. In this case, the brakeman did nothing to prevent the train from being operated too fast. He may have been hesitant to take action because the engineer was his superior. Or it may be that the brakeman did not realize that the train was moving too fast.

The determination of what constitutes a "restricted" speed is based on an engineer's judgment. If an engineer had never struck a train or obstruction while running at restricted speed, he may not know when he is running too fast for the prevailing conditions. Since the safe operation of a train is dependent on the engineer's judgment, carriers should assure that their engineers are trained adequately in judging their trains' speeds. There is a need to study ways to teach employees to comply with restricted speed. Effective action under the restricted

speed rule requires knowledge of the stopping distance of a train at various speeds under prevailing conditions and the distance at which a train or obstruction can be perceived in each portion of track. Employees must know how to combine these two factors to determine the acceptable speed for each circumstance.

As restricted speed is now defined, the restricted speed rule is unenforceable except where the maximum, allowable speed is exceeded. Unless the train strikes something or incurs other trouble specifically named in the restricted speed rule, the rule has not been violated. Despite the fact that Extra 6330 West was moving faster than the 7 mph estimated by the engineer and the brakeman, the restricted speed rule was not violated until he hit Extra 2278 West. If safe operation of a train is dependent upon the engineer's judgment of the proper speed for given conditions, the carrier should provide a dependable speed indicator.

If Rule 99 had required the crew of Extra 2278 West to provide flag protection against a following train, the collision could have been prevented. Even if Rule 99 had required protection only against a train moving at restricted speed, the oncoming Extra 6330 West, moving at excessive speed, would have received a warning sooner than when the engineer saw the rear of Extra 2278 West. But since Rule 99 states that the crew of a train in a block protected by automatic block signals does not have to flag following trains, Extra 6330 West did not receive advance flag warning.

Locomotive Cab Crashworthiness

After the impending crash was recognized by the engine crew of Extra 6330 West, the action of the fireman could not be accounted for by the engineer or brakeman. Since he was found outside the cab, it is probable that he attempted to leave the locomotive cab. If there had been a crash refuge available in the cab, the fireman may not have been tempted to leave the cab and he could have survived the crash.

Backup System

A backup system such as automatic train control probably would not have prevented this accident under the circumstances. However, with the restricted visibility in that block because of the high rock wall on the inside of the curve, a "stop" indication instead of a "stop-and-proceed" indication at signal 653 would be justified.

Radio

The use of radio to enhance safety in train operation has fallen short of its potential. In at least eight cases that the Safety Board has examined, carriers have not been positive in their policies regarding

the use of radio. Consequently, lax and questionable practices have developed. Employees have developed too much dependence upon radios without the proper guidance and analysis of the effects of imprecise procedures.

Sometimes the use of radio where there are insufficient guidelines is as bad as the nonuse or lack of a radio. Confusion results when there is uncertainty as to whether a train is radio-equipped. There is also an unknown element when it is not known under what conditions or circumstances a radio will be used to alert other trains or employees of an emergency or an abnormal situation. Therefore, more positive controls are necessary. 2/

If Extra 2278 West's locomotive radio had been functioning properly when Extra 2278 West stalled, or if the conductor had been provided an operable portable radio, the engineer or conductor could have cautioned the oncoming Extra 6330 West that the caboose was stopping in a hazardous location. The actions of Extra 6330 West's engineer indicate that he probably expected a situation ahead that would delay his train, because he had advised the train following him each time Extra 6330 West stopped. If that is true, it emphasizes the danger of uncontrolled radio use and the resultant dependence upon it.

To realize the radio's potential, radio rules must be enforced consistently and they must be supplemented by dependable equipment on all trains. Trains should be equipped with radios as a standard procedure. Confusion results when it is not known whether a train is equipped with radios, and when and how they are to be used is not specified, but is left as an option for the crewmembers to exercise.

At the present time the FRA is studying the problems in railroad radio application and is considering rules to govern its use.

CONCLUSIONS

1. Extra 2278 West was operating in compliance with the applicable Penn Central operating rules.

2. The crew of Extra 2278 West was not required by Rule 99 to provide flag protection to the rear or for the adjacent track.

3. Rule 34 was not adequate to assure the safe operation of Extra 6330 West.

2/ Recommendations on use of railroad radio, issued May 17, 1972. Safety Recommendations R-72-9 and 10.

4. The Safety Board concludes that the engineer and brakeman of Extra 6330 West did not comply with Rule 34 in that they did not stop the train when it moved through the occupied block at excessive speed. There is conflicting testimony whether Extra 6330 West actually stopped at signal 653; however, in either case, it did not affect the outcome of the accident.

5. Although there were certain discrepancies in the indication displayed by signal 653, under the rules, the signal had to be considered a "stop-and-proceed" indication.

6. With the available visibility and braking capability, Extra 6330 West could have stopped short of collision if the train had been running at the 7 mph estimated by the engineer and brakeman.

7. Because of the damage and the severity of impact, the Safety Board does not believe that the positions of the locomotives' controls after the collision necessarily indicate their positions approaching the point of impact.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer and brakeman to assure the operation of the train at a speed slow enough to stop it within the visibility range. This violated the restricted speed rule required by the signal indication.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board has made two recommendations to the Administrator, Federal Railroad Administration. (See Appendix D.) Also, the Safety Board believes that two recommendations made to the Federal Railroad Administration concerning the head-on collision of two Penn Central trains at Herndon, Pennsylvania, on March 2, 1972, have not been implemented fully. Since these recommendations are applicable to the accident at Leetonia, the Safety Board reiterates the following recommendations.

1. The FRA promulgate regulations to require that a railroad equipped with radio communication facilities install radios in appropriate parts of trains and maintain them in operating condition, unless all personnel involved are notified to the contrary by appropriate railroad procedures, such as a train order or general order. (Recommendation R-73-10)

2. The FRA, in the promulgation of regulations governing railroad operating rules, where responsibility for safe operation of the train is assigned jointly to the engineer and the conductor, require that they be located and informed so that they can make quick, effective decisions. (Recommendation R-73-11)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD.

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

February 17, 1976

APPENDIX A

CREW INFORMATION

Extra 6330 West -- The engineer was hired by the PC on August 20, 1957, and was promoted to engineer on November 26, 1963. He was fully qualified on Penn Central requirements and was familiar with the route over which he was operating. He last attended a rules class on September 15, 1974.

The fireman was hired on April 8, 1970. He was promoted to engineer on March 25, 1975, after having attended the engineer training course conducted by the Penn Central. He was qualified over the territory in which the accident occurred. He last attended a rules class on January 8, 1975.

The head brakeman was hired on September 9, 1969. He had been a regular crewmember on Extra 6330 West for about 3 weeks. His last physical was in May 1975. He attended a rules class on September 6, 1974.

Extra 2278 West -- The engineer was hired on June 28, 1946, and was promoted to engineer in December 1951. He was a regular member of the crew pool that operates train FC-9 (Extra 2278 West). He last attended a rules class on March 6, 1974.

The fireman was a regular member of the crew pool that operates train FC-9 (Extra 2278 West). He began work as a fireman on July 2, 1970.

The head brakeman was hired on March 2, 1971. He last attended a rules class on November 7, 1974.

The conductor was hired on April 4, 1964. He last attended a rules class on January 25, 1974.

The flagman was hired on June 25, 1956. He last attended a rules class in November 1974.

Extra 6259 East -- The engineer was hired on July 1, 1941. He last attended a rules class on November 6, 1974.

The head brakeman was hired May 29, 1973.

APPENDIX B

Excerpts from Penn Central Transportation Company's
Rules for Conducting Transportation.

BLOCK SIGNAL SYSTEMS

AUTOMATIC BLOCK SIGNAL SYSTEM (ABS)--A block signal system wherein the use of each block is governed by an automatic block signal, cab signal, or both.

*****

RESTRICTED SPEED—Proceed prepared to stop short of train, obstruction, or switch not properly lined looking out for broken rail, not exceeding 15 miles per hour.

NOTE—Speed applies to entire movement.

*****

34. All members of the crew must, when practicable, as soon as the next signal ahead affecting the movement of their train or engine becomes clearly visible, communicate the indication to each other by name, and thereafter continue to observe the signal and call any change of indication until it is passed.

If train or engine is not operated in accordance with the signal indication, or other condition requiring speed be reduced, other members of the crew must communicate with crew member controlling the movement at once and if necessary stop the train.

*****

99. When a train stops under circumstances in which it may be overtaken by another train, a member of the crew must go back immediately with flagging equipment a sufficient distance to insure full protection, placing two torpedoes, and when necessary, in addition, displaying lighted fusees.

When recalled and safety to the train will permit, he may return.

When conditions require, he will leave the torpedoes and a lighted fusee.

The front of the train must be protected in the same way when necessary.

When a train is moving under circumstances in which it may be overtaken by another train, a member of the crew must take such action as may be necessary to insure full protection. By night, or by day when the view is obscured, lighted fusees must be dropped off at proper intervals.

When day signals cannot be plainly seen, owing to weather or other conditions, night signals must also be used.

Conductors and enginemen are responsible for the protection of their trains.

When a pusher engine is assisting a train, coupled behind the cabin car, and the member of the crew that protects the rear end of the train is riding in the cabin car, the requirements as to the use of fusees should be met by dropping them off between the cabin car and pusher engine on the track the train is using, and not between that track and an adjacent track.

NOTE—When trains are operating under automatic block signal system rules or traffic control system rules, the requirements of Rule 99 do not apply for following movements on the same track.

NOTE—When trains are operating under manual block signal system rules, the requirements of Rule 99 will not apply for following movements on the same track where Rule 316 is in effect, except when required by train order or timetable special instructions.

*****

Rules Governing the Movement of Trains in the Same Direction by Block Signals

251. On portions of the railroad, and on designated tracks so specified in the timetable, trains will run with reference to other trains in the same direction by block signals whose indications will supersede the superiority of trains.

*****

Rule 291

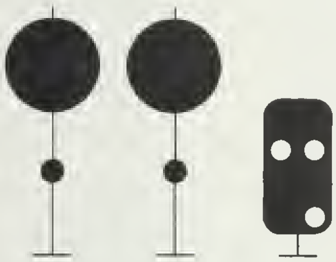

FIG. A FIG. AA FIG. A-1

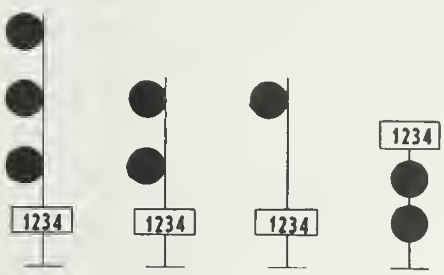

FIG. B FIG. B-1 FIG. B-2 FIG. B-3

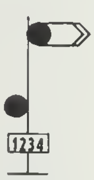

FIG. C

INDICATION—Stop; then proceed at Restricted speed.

NAME: Stop and proceed.

NOTE—Where, in addition to the number plate, a letter G, grade marker, is displayed as part of these aspects, Rule 290 applies.

*****

Enginemen

400N-3. Report to and receive instructions from the Superintendent or other designated officer. They will be governed by current mechanical, electrical and air brake instructions pertaining to the safety, inspection, preparation, and operation of trains and engines. They must comply with the orders of the Road Foreman of Engines, Trainmaster or other designated officer within their jurisdiction.

They must obey the instructions of Station Masters, Station Agents, Yard Masters, and Operators within their jurisdiction; and the conductor in charge of their train as to general management of their train, unless by so doing they endanger its safety or commit a violation of the rules.

They must be qualified on type of engine to which assigned including any devices or auxiliaries attached thereto. At a point where no mechanical forces are on duty and except on through trains, they will check the prescribed form in the cab to be sure that the unit or units of the engine consist have been inspected within the previous 24 hour period for road service or within one calendar day in yard service.

If the engine unit or units are not within date they will make an inspection. After making inspection, they will then record date, time and location on the prescribed form in the cab and prepare and sign regular work report.

APPENDIX B

At points where mechanical forces are employed and on duty, they will accept the inspection of the mechanical forces, except air brake test, as to the condition of the engine.

They will at the end of the trip make written report on the prescribed forms.

They will be responsible for the observance of all signals controlling movements accordingly and the regularity of speed between stations, exercise discretion, care, and vigilance in moving the engine with or without cars to prevent injury to persons, damage to property, and lading, avoiding collisions and derailments. While acting as pilot they will operate the engine unless otherwise instructed and when in charge of the engine to which no qualified conductor is assigned or is disabled they must perform the duties of and conform to the rules relating to conductors. They will require the assistance of crew members in any duties relative to the prompt and safe movement of their trains, engine and cars, promptly reporting irregularities or failures.

They must not allow any member of the crew to operate the engine except under their personal supervision. They will be responsible for the proper operation of the engine and must not leave it while on duty except in case of necessity in which case the engine must be secured.

They must, if anything withdraws attention from constant lookout ahead, or weather conditions make observation of signals or warnings in any way doubtful, at once so regulate speed as to make train progress entirely safe.

When a train has more than one engine the rules apply alike to the engineman of each engine, but the use of the engine bell, whistle and air brake except in emergency must be limited to the leading engine.

The engineman is responsible for the vigilance and conduct of other employes on the engine. He will see that they are familiar with their duties and instruct them if necessary.

APPENDIX C

Results of actual stopping tests performed with Extra 6312 West on June 10, 1975:

Train consist......Diesel units 6312-6309-6341-3009
Loads 100
Empties None
Tons 8,249

Start of Tests	Speed (mph)	Stopping Distance (From point caboose sighted)	Distance to caboose (From point stopped)	Automatic Brake Reduction (Pounds of air)	Throttle Position
Signal 653	3	156	258	15	2
Signal 653	10	355	59	23	6
Signal 653	17	740	326+	30	8

Results of simulated tests for a train similar to Extra 6330 West of June 6, 1975:

Simulated conditions for tests:

a) Train on level track
b) Weather clear - Temperature 55°F
c) Brakes on locomotive operative
d) Ascending grade disregarded
e) Curvature disregarded

STOPPING DISTANCE (EMERGENCY APPLICATION)

Test Speed (mph)	Brake Pipe Pressure 80 psi	Brake Pipe Pressure 95 psi
5	58 Ft	52 Ft
10	155 Ft	145 Ft
12	203 Ft	191 Ft
15	289 Ft	271 Ft

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX D

ISSUED:

Forwarded to:

Honorable Asaph H. Hall
Administrator
Federal Railroad Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-76-6 through R-76-9

About 11:00 p.m. on June 6, 1975, three freight trains of the Penn Central Transportation Company were involved in a collision near Leetonia, Ohio. Extra 6330 West collided with the rear of standing Extra 2278 West. Immediately thereafter, Extra 6259 East, which was on an adjacent track, struck the wrecked cars from the other two trains. One employee was killed and seven others were injured. Property damage amounted to $1.25 million.

According to Operating Rule 99, Extra 2278 West was not required to flag following trains. According to Operating Rule 291, Extra 6330 West was permitted to proceed past signal 653, which displayed a "stop and proceed" aspect because the block was occupied. Under ideal visibility conditions, the maximum unobstructed view westward from signal 653 was about 1,370 feet. Extra 2278 West was stopped just beyond this range. Also, visibility was decreased because of darkness. The protection that Extra 2278 West depended on was (1) The protection afforded by signal 653, and (2) the compliance with the restricted speed rule by the engineer of a following train. In this case, the protection was not adequate to prevent a collision.

The engineer of Extra 6330 West failed to comply with the requirements of Rule 291. Whether he did or did not stop at signal 653 before proceeding by it, he should have been operating his train at restricted speed. He might have been expecting a radio communique from the preceding train or he might have thought his speed was such that he could have stopped short of a hazard. Nevertheless, the system failed. The circumstances of this accident show the need to provide additional protection for trains in occupied blocks when a train stops in a spot where approach visibility is limited or obstructed.

The accident also indicates that radio procedures used by Penn Central crews were not well defined and that enforcement was lax. Basically, the procedures used by Penn Central crews have evolved gradually through trial and error. The crews of Extra 2278 West and Extra 6330 West apparently were dependent on their radios to report unusual circumstances. The engineer of Extra 6330 West had used his radio regularly that evening to report his frequent stops and starts to a following train. Even though the engineer of Extra 2278 West knew his radio would not transmit, his actions after his train stalled indicated that he still considered the radio to be the most expedient means of reporting his disabled locomotive unit, because he used the radio of another train to report his unit's failure.

These actions indicate that the crews were accustomed to radio communications and dependent upon them to varying degrees. This dependence may have detracted from the effectiveness of other safeguards. Also, the crews could not rely dependably on another train's being equipped with radio equipment since trains often were dispatched without radios and there was no policy in effect to make this known to other employees.

This accident illustrates a lack of guidelines to operating personnel from Penn Central management about proper radio procedures for them to follow if a train is stopped in an area of restricted visibility.

Therefore, the National Transportation Safety Board recommends that the Federal Railroad Administration:

1. Promulgate regulations to prohibit trains from operating in occupied blocks except through the authority of a train order or by some other procedure with similar safeguards. (Recommendation R-76-6) (Class II, Priority Followup)

2. Establish guidelines for and require carriers to establish radio procedures to insure that trains which stop in restricted visibility areas will notify by radio or flag trains to the rear. (Recommendation R-76-7) (Class II, Priority Followup)

3. Require that trains be equipped with operable radios and that railroad management provide guidelines for their use in normal service and in emergency situations. (Recommendation R-76-8) (Class II, Priority Followup)

4. Continue the investigation of the crashworthiness of locomotive cabs with emphasis on personnel safety and consideration of a readily accessible crash refuge. (Recommendation R-76-9) (Class II, Priority Followup)

APPENDIX D

TODD, Chairman, McADAMS, THAYER, BURGESS, and HALEY, Members, concurred in the above recommendations.

By: Webster B. Todd, Jr.
Chairman

74994

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

REAR END COLLISION OF AN ALASKA RAILROAD FREIGHT TRAIN WITH A PASSENGER TRAIN

NEAR HURRICANE, ALASKA JULY 5, 1975

REPORT NUMBER: NTSB-RAR-76-3

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Railroad Accident Report July 5, 1975 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

About 3:46 p.m. on July 5, 1975, an Alaska Railroad freight train, Extra 1502 South, collided with the rear of passenger train No. 5, which had stopped south of Hurricane, Alaska, to permit the passengers on the train to view Mt. McKinley. All cars of the passenger train and the first four locomotive units of the freight train were derailed. Sixty-two persons were injured and one of the injured subsequently died.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer of Extra 1502 South to operate the braking system on the locomotive properly and the failures of both traincrews to comply with railroad operating rules.

As a result of its investigation, the Safety Board made three recommendations to the Federal Railroad Administration concerning improvement and compliance with operating rules and a modification of locomotive brake valves.

17. Key Words Railroad accident; rear end collision; train orders; flagging; emergency braking.		18. Distribution Statement This document is available through the National Technical Information Service, Springfield, Virginia 22151	
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FOREWORD

This report is based upon an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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File No. SS-R-40

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: February 19, 1976

REAR END COLLISION OF AN ALASKA RAILROAD FREIGHT TRAIN WITH A PASSENGER TRAIN NEAR HURRICANE, ALASKA JULY 5, 1975

SYNOPSIS

About 3:46 p.m. on July 5, 1975, an Alaska Railroad freight train, Extra 1502 South, collided with the rear of southbound passenger train No. 5, which had stopped south of Hurricane, Alaska, to permit the passengers on the train to view Mt. McKinley. All cars of the passenger train and the first four locomotive units of the freight train were derailed. Sixty-two persons were injured and one person died as a result of the collision. The estimated cost of damages was over $558,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer of Extra 1502 South to operate the braking system on the locomotive properly and the failures of both traincrews to comply with railroad operating rules.

FACTS

The Accident

Passenger Train No. 5 -- About 12:40 p.m. on July 5, 1975, Alaska Railroad (ARR) passenger train No. 5 departed Healy, Alaska, on time. At Colorado, 61 miles south of Healy, No. 5 passed Extra 1502 South.

When train No. 5 was near Colorado, the conductor instructed the front brakeman to deliver a train order to the flagman. When he arrived at the rear car, the front brakeman delivered the train order and assisted the flagman to make temporary repairs to the air conditioning system of that car. Then they checked the malfunctioning air conditioning system on the 10th car. They then discussed whether it was a good time for the flagman to eat lunch. The flagman then went forward to the diner, the sixth car. The front brakeman remained on the 10th car and continued to work on the air conditioning system.

As No. 5 approached Hurricane, 15.7 miles south of Colorado, the conductor radioed instructions to the engineer to stop the train 2.2 miles south of Hurricane so that passengers could view and photograph Mt. McKinley. 1/ None of the other crewmembers were told about the planned stop.

No. 5 made a scheduled stop at Hurricane and departed at 3:41 p.m., 6 minutes later than the timetable schedule of 3:35 p.m. No crewmember left a lighted fusee at Hurricane. 2/ The train proceeded to the mountain stop, where it was stopped for about 1 minute.

Extra 1502 South -- On July 5, 1975, at 12:27 a.m., Extra 1502 South, a freight train consisting of five locomotive units, nine empty and two loaded cars, departed Healy after the brakes had been tested by the traincrew. The train was authorized by train order to run ahead of No. 5 from Healy to Curry -- a distance of 100 miles. However, according to the rules of the carrier, the extra train was still required to permit the superior train to pass if the extra train was delayed and, consequently, was operating on the schedule of the superior train.

Since Extra 1502 South had been delayed en route, and since work had to be performed at Colorado, the conductor decided to allow No. 5 to pass at Colorado. Consequently, the train order was fulfilled when No. 5 passed Extra 1502 South. Extra 1502 South departed Colorado at 3:15 p.m. At 3:27 p.m., Extra 1502 South passed Honolulu; the conductor reported the passing as required, and while so doing was informed by the train dispatcher that a train order would be transmitted to Extra 1502 South when it arrived at Hurricane.

Extra 1502 South passed Hurricane at about 3:43 p.m. and did not stop although it was required to do so. The conductor reported to the train dispatcher that the train was at Hurricane and that he was ready to copy the train order. The engineer heard the radio conversation between the conductor and the train dispatcher concerning the transmittal of the train order, and was attempting to copy the order as the train moved southward from Hurricane.

The Collision -- The crew of Extra 1502 South first saw No. 5 as the locomotive rounded a 1° curve about 3,000 feet north of the rear of No. 5. The speed of Extra 1502 South at that time was 40 mph. The engineer said that he applied the brake lightly, because he believed that he had sufficient distance in which to stop the train. After seeing No. 5, the front brakeman asked the engineer if he could copy the order

---

1/ In its Operating Circular No. 9, the Alaska Railroad made provisions for passenger trains to be stopped so tourists could view the mountain. (See Appendix C.)

2/ The 10-minute fusee would have insured a 10-minute separation of the trains.

but the engineer refused the request. Since the train was approaching a road crossing and the engineer still appeared to be busy, the front brakeman blew the crossing whistle signal. The front brakeman became concerned when the locomotive was about 1,500 feet north of No. 5 and still moving at a considerable speed. He reached for the emergency valve, but the engineer applied the brakes in emergency before the front brakemen could operate the valve. After the engineer applied the emergency brake, he moved the independent brake valve handle forward to the full application position and then downward on the release bail; this nullified the emergency application on the locomotive.

Extra 1502 South collided with the rear of No. 5 at a speed of approximately 25 mph, just as No. 5 had begun to move.

Neither of the crewmembers on the locomotive of Extra 1502 South had seen a flagman nor a lighted fusee as they approached the rear of No. 5.

Within 5 minutes after the collision, the Elmendorf Air Force Base Air Rescue unit was notified and they immediately dispatched rescue helicopters from Anchorage and Fairbanks to the scene. Sixty-two injured were transported to hospitals in Anchorage of which twenty-two passengers and one crewmember were admitted to the hospital. One of the injured died as a result of his injuries. Many of the more serious injuries were incurred when passengers were thrown into, and their abdominal areas struck, the edges of tables in the dining and lounge cars.

Damages

The rear of No. 5 stopped 76 feet south of the point of impact. All cars were derailed. Car 10, a dome car, was heavily damaged when the underframe buckled. (See Figure 1.) The remaining passenger cars were damaged slightly.

The first four locomotive units of Extra 1502 South derailed. The couplers between the locomotive units were bent. The impact sheared the engine mounting bolts of the first unit and shifted the main generator. The other units also were damaged.

About 500 feet of rail were turned over and torn out as a result of the collision and the derailments.

Costs of damages were estimated as follows:

Passenger train No. 5	$ 483,660
Extra 1502 South	55,000
Track	20,000
Total	$ 558,660

Figure 1. Damaged dome car of train No. 5.

The Accident Site

The single main track, south from Hurricane, is straight until a point 3,121 feet north of the collision. There, a 1° curve to the east extends southward 1,597 feet. The track is then straight for 948 feet, where a 4° curve to the west begins; the curve continues beyond the collision point. For southbound trains, the grade is 1.75 percent descending, from about the beginning of the 1° curve to the collision point. The Anchorage-Fairbanks highway crosses the main track 2,079 feet north of the collision point. (See Figure 2.)

The trains collided in daylight; the weather was clear and the temperature was 70°F.

Method of Operation

The ARR is owned by the U.S. Government and is operated by the Federal Railroad Administration. Trains are operated between Healy and Anchorage by timetable and train orders. There is no automatic block signal system.

Train orders can be issued by the train dispatcher directly to the traincrews by radio. Radio Rule No. 516 prescribes the manner in which train orders must be transmitted:

> "Train, engines or equipment must be stopped while copying and repeating train orders and clearance. Operating rules will apply for the transmission of train orders by radio the same as by telephone."

During the investigation, some employees disclosed that they copied train orders while the train was moving if they considered it safe. There is no requirement that the dispatcher determine whether a train is standing before he issues a train order.

The railroad's operating rule No. 91 requires:

> "Unless some form of block signal is used, trains in the same direction must keep not less than 10 minutes apart, except in closing up at stations. Lighted fusees may be used for this purpose. In closing up, the following train must run at restricted speed. Operators when on duty must space trains with train order signal."

This means that following trains should not pass a station where time is shown in the timetable until 10 minutes after the scheduled departure time for the train. (See Appendix A.)

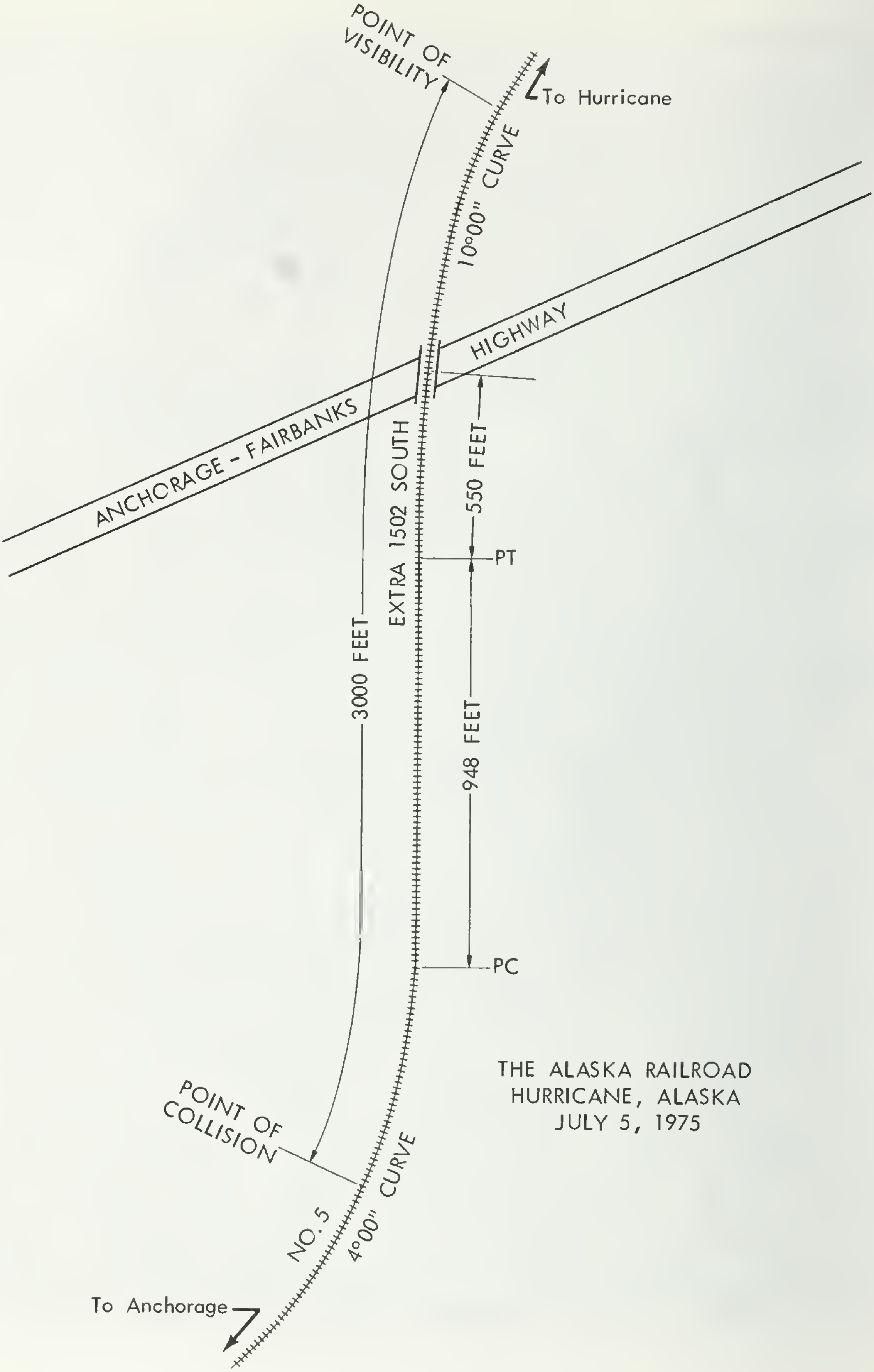

Figure 2. Accident site.

Rule 99, in part, requires:

"When a train is moving under circumstances in which it may be overtaken by another train, the flagman must drop lighted fusees at proper intervals and take such other action as may be necèsssary to insure full protection.

"When a train stops under circumstances in which it may be overtaken by another train, the flagman must go back immediately with flagman's signals a sufficient distance to insure full protection, placing two torpedoes and when necessary, in addition, displaying lighted fusees. When recalled and safety of the train permits, he may return, leaving the torpedoes and when conditions require, a lighted fusee.

"When it is known by the engineman that his train will be delayed he must immediately whistle out a flagman. When ready to proceed he will recall the flagman."

In the operation of the trains' braking systems, Rule 440, in part, requires:

"(c) No attempt must be made to release the brakes on a train after an emergency brake application until train has stopped, and time limit as specified in Rule 434 has been complied with."

The maximum authorized speed for trains in the vicinity of the accident was 35 mph.

Crewmembers on passenger trains were permitted to eat meals in the dining car. However, instructions had not been issued as to when and how this would be accomplished; this was left to the discretion of the conductor.

Train Equipment

Passenger Train No. 5 -- No. 5's equipment consisted of two type F-7 diesel-electric locomotive units manufactured by ElectroMotive Division of General Motors Corporation, two baggage cars, five coaches, two dome coaches, a cafe-lounge car, and a dining car. The cars were constructed of steel and equipped with tight-lock couplers. The rear of the last car was equipped with a red oscillating light and marker lights. The oscillating light operated during all train movements.

Extra 1502 South -- The five locomotive units of Extra 1502 South were type F-7, manufactured by the ElectroMotive Division of General Motors Corporation. The first three units had No. 24 RL brake systems and the last two units had No. 6 BLC brake systems. Each unit was provided with clasp brakes which were equipped with high-phosphorous brakeshoes. The independent brake valve of the 24 RL brake system had a bail under the brake handle which, when depressed by a downward movement of the brake handle, released the brakes on the locomotive. This can function with the brake handle in any position. With the independent brake valve, the brakes are released fully when the handle is in its full rearward position and they are applied fully when the handle is in its full forward position.

Speed-recording devices had been installed on the locomotive units. After the accident, the device on the first locomotive unit was calibrated and found to be accurate within 1 mph at 32 mph. The tape showed that Extra 1502 South exceeded the 35-mph limit during the 4 miles preceding the collision and at three points reached 40 mph. Extra 1502 South was moving at 40 mph when the emergency brake application was made just before the collision. The train first began to decelerate 1,500 feet before the collision. A mark on the tape, which could have resulted from the impact, indicates that the speed at that time was about 25 mph.

The remainder of the train consisted of five boxcars, a baggage car, a flatcar, and two cabooses, all of which were empty. Two loaded cars had been set out of the train before the collision. The freight cars were equipped with AB brakes and the baggage car had U-12 BD brakes.

The locomotives, cabooses, and some baggage cars were equipped with permanently installed radios. With these radios, crewmembers could converse with each other, with the crewmembers of other trains, with personnel at the train dispatcher's office, and with personnel at other wayside stations.

The Engineer of Extra 1502 South

The engineer of Extra 1502 South was hired by the Alaska Railroad on July 2, 1957, as a freight station employee. On February 22, 1970, he was transferred to the operating department as a student fireman and on March 31, 1974, he was promoted to engineer. During the period from June 21, 1975, until July 5, 1975, he had worked 2 days as a fireman on passenger trains, 2 days as a fireman on freight trains, 3 days as an engineer on freight trains, and 4 days as an engineer on a switching crew; on 3 days he was not on duty.

Tests

After the accident, tests were performed to determine when No. 5 would have been visible to the crewmembers of Extra 1502 South and to determine how long it would take to stop Extra 1502 South from various speeds.

The visibility tests showed that No. 5 would have become visible to the locomotive crewmembers of Extra 1502 South when their locomotive was about 3,000 feet from No. 5. From that point on, the standing train remained visible.

Four stopping-distance tests were conducted using a train with the same type of equipment as Extra 1502 South. During the first test, the train was operated according to all railroad rules and requirements between Colorado and the accident site. A full service application of the brakes was made at the point where No. 5 first could have been seen by the locomotive crew. With the train moving at a speed of 35 mph, the train was stopped in 1,362 feet. Three additional tests were made to determine stopping distances following an emergency application of the brakes at various speeds. Results of these tests were as follows:

Test No.	Speed mph	Distance to stop feet
1	33	705
2	36	925
3	42	1,215

ANALYSIS

The Accident

As a result of its investigation, the Safety Board concludes that the engineer and brakeman of Extra 1502 South saw the rear of train No. 5 about 3,000 feet in advance of the collision point. The engineer had been preoccupied with copying a train order and allowed Extra 1502 South to pass the point where a service brake application would have stopped the train short of a collision. When he realized what had happened, the engineer made an emergency brake application.

When the engineer moved the independent brake valve forward to the full-application position and then pressed down on the release bail, the emergency brake application on the locomotive units was released and the total braking capability of the train was reduced. Consequently, the braking effort was not sufficient to stop the train, moving at 40 mph on a 1.75-percent descending grade, short of No. 5. However, the stopping-distance tests showed that the train could have been stopped short of a collision had full emergency brakes been applied.

The engineer stated that he believed an application of the independent brake in addition to the emergency brake application would create more braking force. Consequently, he had slammed the independent brake handle forward, but had forgotten that a downward motion of the handle on the release bail would release the emergency application on the locomotive.

Operating Rules and Practices

This accident appears to be the culmination of a series of rule violations and poor practices. If the crews of Extra 1502 South and No. 5 had complied with any one of the following operating rules, the accident would have been avoided.

Rule 91 puts the responsibility for maintaining a 10-minute separation upon the following train. Although the rule allows the use of fusees to maintain separation, it does not require them. If the flagman of No. 5 had left a fusee on the track at Hurricane, Extra 1502 South would have had to stop and wait until the fusee burned out. Even without the fusee, Extra 1502 South was not permitted to leave Hurricane until 3:45 p.m., 10 minutes later than No. 5's scheduled departure time. If the engineer of Extra 1502 South had waited, his train would not have collided with No. 5 at 3:46 p.m. Further, if the engineer had not exceeded the speed limit, more time would have been consumed in traveling the distance between Hurricane and the accident point. There was no safeguard to assure that trains maintained a 10-minute separation in case the following train did not wait 10 minutes. No. 5 should have been required to leave a 10-minute fusee on the track at Hurricane when it departed.

Rule 99 was clear in its requirement that a flagman must protect the train when a train stops as No. 5 did at Hurricane and at the mountain. It was not specific as to when the flagman should have left a lighted fusee; however, it seems that a prudent conductor would require it if he knew that a train was following. Since the engineer did not whistle out a flagman, the question arises whether it was the practice to flag under circumstances such as those at Hurricane and at the mountain stop.

Although the absence of a flagman at the rear of No. 5 at the mountain stop may not have been a causal factor, it is another violation of Rule 99. These violations indicate the need for a complete review of the enforcement policies and practices on the Alaska Railroad. The conductor should have instructed the crewmembers to be sure that when the flagman was eating, the brakeman assumed the flagman's responsibilities. Although it was the conductor's responsibility to see that the train was protected, the experienced brakeman should have flagged without specific instructions to do so since he knew the flagman was eating lunch.

Rule 516 required that the train be stopped if any member of the crew was required to copy a train order. The engineer of Extra 1502 South had heard the conversations between the train dispatcher and the conductor concerning the copying of a train order at Hurricane. He knew the requirements of Rule 516 and even though the conductor did not instruct him to stop at Hurricane to copy the train order, he should have done so.

The front brakeman, who was located in the cab of the locomotive with the engineer, volunteered to copy the train order, but the engineer declined his offer and continued to copy the order. The failure of the engineer to give his full attention to the operation of the train placed the train in a position where an emergency brake application was required to control the train. If the engineer had been giving his full attention to the operation of the train, he could have controlled and stopped Extra 1502 South short of the passenger train.

It could not be determined why the engineer of Extra 1502 South did not stop to copy the train order as required by Rule 516. However, other crewmembers also stated that they had copied train orders while the train was moving when they considered it safe. This raises the question of whether the rule had been enforced.

Rule 440, governing emergency brake applications, required that no attempt be made to release any of the brakes following an emergency application until the train has stopped. The engineer violated this when he applied the independent brake, which released the emergency application.

Air Brake System on Locomotive of Extra 1502 South

The 24 RL locomotive air brake equipment has an independent brake valve which permits the release of the locomotive brakes in all positions of the valve handle. This is different than most systems, which only permit this operation to be performed in one or two settings. There is no valid reason for the release-feature design of the 24 RL independent brake valve, which permits the release of the brakes at times when they should stay applied.

The 24 RL brake equipment has been superseded by the 26-type brake equipment, which does not use this type of independent brake valve. There are, however, a number of locomotives still in service which have 24 RL brake equipment.

CONCLUSIONS

1. The movement of No. 5 was not protected as required by the operating rules at Hurricane or at the mountain stop.

2. The railroad had no procedure to detail the responsibilities of the flagman to another crewmember while the flagman is eating a meal in the diner.

3. The front brakeman, who knew that the flagman had gone forward to the dining car, should have assumed the duties of the flagman.

4. The locomotive crew of Extra 1502 South observed No. 5 in sufficient time to have stopped Extra 1502 South short of the collision.

5. If the crews of Extra 1502 South and of No. 5 had complied with any one of the following operating rules, the accident would have been prevented:

    a. Rule 516, which required the train to be stopped while crew-members copied train orders.

    b. Rule 91, which required the spacing of following trains by 10 minutes.

    c. Rule 99, which required the display of a lighted fusee on the track if a train slowed down or stopped.

    d. The maximum speed, which prohibited Extra 1502 South from being operated faster than 35 mph.

6. The Alaska Railroad had not established procedures to insure compliance with Rule 516.

7. The arrangement of the air brake system on the locomotive of Extra 1502 South permitted the engineer inadvertently to release the emergency brake application on the locomotive.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer of Extra 1502 South to operate the braking system on the locomotive properly and the failures of both traincrews to comply with railroad operating rules.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board made three recommendations to the Administrator, Federal Railroad Administration. (See Appendix D.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

February 19, 1976

APPENDIX A

SOUTHWARD			ANCHORAGE-HEALY SUBDIVISION		NORTHWARD
First Class 5 DAILY	Capacity of Siding	Rule 6-A Signs	TIME TABLE 95 May 18, 1975 STATIONS	Mile post	First Class 6 DAILY
L 12 40 PM		BJKOP R WXYZ TO	**HEALY** ②①	358.1	A 4.45 PM
			2.4		
l 12.47	14	P	GARNER	355.7	f 4.37
			7.8		
s 1:20	50	PXY	**McKINLEY PARK** ②①	347.9	s 4 12
			4.2		
f 1:30		P	LAGOON	343.7	f 3 57
			9.3		
f 1 49	25	P	CARLO	334.4	f 3.38
			7.7		
f 2:04	100	PY	WINDY	326.7	f 3 23
			7.2		
s 2:19	36	P	CANTWELL	319.5	s 3.09
			7.0		
f 2:31		P	SUMMIT	312.5	f 2.57
			8.2		
6 **f 2:45**	83	PXY	BROAD PASS ②	304.3	**5** **f 2:45**
			7.2		
f 3:00	82	P	COLORADO	297.1	f 2:30
			8.4		
f 3:15	111	P	HONOLULU	288.7	f 2:15
			7.3		
f 3:35	48	P	HURRICANE ②	281.4	f 1.55
			7.6		
f 3:50	42	PY	CHULITNA	273.8	f 1:37
			5.4		
f 4:02	42	P	CANYON	268.4	f 1:24
			5.2		
f 4:12	100	P	GOLD CREEK	263.2	f 1:13
			5.5		
f 4:22	29	P	SHERMAN	257.7	f 1.03
			9.2		
f 4:40	#1-60 #2-50	PWXY	CURRY ②①	248.5	f 12:46
			12.3		
f 5:03	58	P	CHASE	236.2	f 12:25
			9.5		
s 5:22	88	P	**TALKEETNA** ②①	226.7	s 12.08 PM
			11.4		
f 5.39	80	P	SUNSHINE	215.3	f 11:50 AM
			6.0		
f 5:48	89	P	MONTANA	209.3	f 11:42
			7.0		
f 5:58	27	P	CASWELL	202.3	f 11:32
			8.4		
f 6:10	32	P	KASHWITNA	193.9	f 11:20
			8.2		
f 6:22	80	PXY	WILLOW ②	185.7	f 11:09
			10.4		
f 6.39	50	P	HOUSTON	175.3	f 10.53
			8.8		
f 6:52		P	PITTMAN	166.5	f 10:41
			6.7		
s 7:02	62	P TO	**WASILLA** ②①	159.8	s 10.32
			9.1		
f 7:25	40	PXY	MATANUSKA	150.7	f 10:10
			9.5		
f 7:40	33	P	EKLUTNA	141.2	f 9:56
			4 9		
f 7:48	42	P	BIRCHWOOD	136.3	f 9.48
			9.7		
f 8:07		P	EAGLE RIVER	126 6	f 9:28
			7.5		
f 8.22	82	PX	WHITNEY	119.1	f 9.13
			4 8		
A 8 35 PM		BKOP R WXYZ TO	**ANCHORAGE** ②①	114.3	L 9:00 AM
DAILY			(243 8)		**DAILY**
7.55 30 82			Time over Subdivision Average Speed Per Hour		7:45 31 45

SOUTHWARD TRAINS ARE SUPERIOR TO TRAINS OF THE SAME CLASS IN THE OPPOSITE DIRECTION
(Additional Stops on Signal - See Following Page)

APPENDIX B

EXCERPTS FROM OPERATING RULES

THE ALASKA RAILROAD

RULES AND REGULATIONS OF THE OPERATIONS DEPARTMENT

EFFECTIVE: MAY 1, 1966

The rules herein set forth govern The Alaska Rail-Road. They supersede all previous rules and regulations inconsistent therewith.

Special instructions may be issued by proper authority.

*****

DEFINITIONS

Engine—A unit propelled by any form of energy, or a combination of such units operated from a single control, used in train or yard service.

Train—An engine, or more than one engine, coupled with or without cars, displaying markers.

Regular Train—A train authorized by time-table schedule.

Section—One of two, or more, trains running on the same schedule displaying signals, or for which signals are displayed.

Extra Train—A train not authorized by time-table schedule. It may be designated as:

Extra—for any extra except work extra.

Work Extra—for work train extra.

Superior Train—A train having precedence over another train.

Train of Superior Right—A train given precedence by train order.

Train of Superior Class—A train given precedence by time-table.

Train of Superior Direction—A train given precedence in the direction specified by time-table as between opposing trains of the same class.

Time-Table—The authority for the movement of regular trains subject to the rules. It contains the classified schedules of trains with special instructions relating to the movement of trains.

Schedule—That part of a time-table which prescribes class, direction, number and movement for a regular train.

Sub Division—A portion of the Railroad designated in the time-table by name.

Main Track—A track extending through yards and between stations, upon which trains are operated by time-table or train order, or both, or the use of which is governed by block signals.

Single Track—A main track upon which trains are operated in both directions.

Station—A place designated on the time-table by name.

Siding—A track auxiliary to the main track for meeting or passing trains.

*****

11. A train or engine finding a fusee burning on or near its track must stop and after fusee has burned out, may then proceed.

In territory designated by the Superintendent, trains finding a red fusee burning on or near its tracks may proceed at restricted speed without stopping.

11 (a). Fusees must not be placed near road crossings, bridges, sign boards, nor places where damage from fire may result.

Fusees must not be thrown off in tunnels. If necessary to use in a tunnel, they must be held in the hand, or placed securely in the earth or ballast in such a manner that it would be impossible for fire to be communicated to woodwork within the tunnel.

*****

18 (a). *Headlights - Yard Engines*: Yard engines will display standard headlight to the front and rear by night. The headlight may be extinguished on the end coupled to cars.

Oscillating red light on rear of trains so equipped must be operated continuously day and night while train is on main track. Red light shall be turned on and turned off by trainmen. Display of red light does not relieve conductors or engineers from providing flag protection, or from complying with other rules.

*****

SUPERIORITY OF TRAINS

71. A train is superior to another train by right, class or direction.

Right is conferred by train order; class and direction by time-table.

Right is superior to class or direction.

Direction is superior as between trains of the same class as specified in time-table.

72. Trains of the first class are superior to those of the second; trains of the second class are superior to those of the third; and so on.

73. Extra trains are inferior to regular trains and have no superiority by direction except as conferred by rule 88 (b).

*****

86. Clearing trains same direction: Unless otherwise provided, an inferior train must clear a first-class train, or a train made superior by a train order, in the same direction, at the time such train is due to leave next station in the rear where time is shown in time-table or train order, except: If the distance between stations is less than three miles, or if the time between stations is less than five minutes, the inferior train must be in clear five minutes or more before the time shown for superior train at station in the rear.

87. Inferior trains must clear opposing superior trains not less than five minutes except at schedule meeting points between trains of the same class where the inferior train must clear the main track before the leaving time of the superior train and failing to clear the main track by the time required by rule must be protected as prescribed by Rule 99.

Necessary identification of trains must be made at meeting points, and at passing points.

*****

91. Unless some form of block signal is used, trains in the same direction must keep not less than ten minutes apart, except in closing up at stations. Lighted fusees may be used for this purpose. In closing up, the following train must run at restricted speed. Operators when on duty must space trains with the train order signal.

*****

99. When a train is moving under circumstances in which it may be overtaken by another train, the flagman must drop lighted fusees at proper intervals and take such other action as may be necessary to insure full protection.

When a train stops under circumstances in which it may be overtaken by another train, the flagman must go back immediately with flagman's signals a sufficient distance to insure full protection, placing two torpedoes and when necessary, in addition, displaying lighted fusees. When recalled and safety of the train permits, he may return, leaving the torpedoes and when conditions require, a lighted fusee.

When it is known by the engineman that his train will be delayed he must immediately whistle out a flagman. When ready to proceed he will recall the flagman.

The front of the train must be protected in the same way when necessary by the forward trainman, or in his absence, by any competent employee.

Conductors and enginemen are responsible for the protection of their trains.

When flagging a train, flagman must spread the flag so that it can be seen by the approaching engineman. Flag should be waved across the track so that it can be distinguished from objects of the same color. Proceed signal must not be given with a fusee or a red flag.

Flagman going out to protect train under requirements of Rule 99 must not have less than six torpedoes and four fusees.

Flagman's equipment will be carried in a rack in cab of steam engines, in a container in cab of diesel engines, and in the baggage compartment of gas or diesel electric motor cars. The required flagging equipment for an engine is one red flag, one white light, 12 torpedoes and 12 fusees. The required flagging equipment for the rear of train is one red flag, one red lantern, 60 fusees and 24 torpedoes.

99 (a). A passenger train flagman, with flagman's equipment, must always appear on the ground at rear of his train immediately after it makes a schedule station stop. By day the red flag must be unfurled.

The flagman must be clothed properly at the different seasons of the year to enable him to perform his full duty in the protection of his train as required by the rules and without having to return to his train for any purpose whatsoever.

99 (b). The flagman must protect his train as prescribed by Rule 99 without waiting for a signal or instructions to do so.

*****

RULES FOR MOVEMENT BY TRAIN ORDER

201. For movements not provided for by timetable, unless otherwise provided, train orders will be issued by authority and over the signature of the Superintendent. They must contain only information or instructions essential to such movement. They must be brief and clear; in the prescribed forms when applicable; and without erasure, alteration or interlineation.

Figures in train orders must not be surrounded by brackets, circles or other characters.

202. Each train order must be given in the same words to all employes or trains addressed.

*****

204. Train orders must be addressed to those who are to execute them, naming the place at which each is to receive his copy. Those for a train must be addressed to the conductor and engineer, and also to anyone who acts as its pilot. The flagman on passenger trains must have a copy of orders and clearance and a copy for each employee addressed must be supplied by the operator.

Orders addressed to operators restricting the movement of trains must be respected by conductors and engineers the same as if addressed to them.

Enginemen and forward brakemen must read train orders, check with each other and have a definite and proper understanding of their requirements. Conductors and trainmen must read train orders, check with each other and have a definite and proper understanding of their requirements.

APPENDIX B

Firemen (when used) and brakemen must call attention of engineers and conductors to any errors or omissions in, or failure to observe train orders or to clear the time of superior trains.

204 (a). Each engineer must receive copies of all train orders, but only the engine by which the train is designated need be referred to in train orders if not equipped with indicators.

*****

220. Train orders once in effect continue so until fulfilled, superseded or annulled. Any part of an order may be either superseded or annulled.

Orders held by or issued for any part of an order relating to a regular train become void when such train loses both right and schedule as prescribed by Rules 4 and 82, or is annulled.

*****

FORMS OF TRAIN ORDERS

*****

B
Directing a Train to Pass or Run Ahead

(1) *No 1 pass No 3 at Willow*
No 3 take siding at Willow
(2) *Extra* 1510 *North pass No 6 at Broad Pass*
No 6 take siding at Broad Pass

Both trains will run according to rule to the designated point and there arrange for the rear train to pass promptly. The order must specify which train will take siding.

When an inferior train receives an order to pass a superior train, authority is conferred to run ahead of the superior train from the designated point.

(3) *Extra* 28 *North run ahead of No* 6 *Anchorage to Matanuska.*

The first named train will run ahead of the second named train between the points designated.

Under examples (1), (2) and (3) when a train is delayed after receiving authority to pass or to run ahead of another train, it will allow the following train to pass.

Train dispatcher will be notified at once by the inferior train, when practicable, and by the superior train at the first open office. When the superior train is allowed to pass, because of delay to inferior train, the order must be considered fulfilled.

Form B orders do not relieve the preceding train from protecting as prescribed by Rule 99.

*****

RAILROAD RADIO RULES — GENERAL

*****

508. Employees shall identify the radio station from which they are speaking by prefacing with proper identification, for example:

"Caboose of Number 23 to engine."
"Yard Engine 7107 to Anchorage Yard Office."
"Caboose of Number 23 calling Dispatcher."
"Engine 1078 to caboose of Number 22."

*****

516. Train, engines or equipment must be stopped while copying and repeating train orders and clearance. Operating rules will apply for the transmission of train orders by radio the same as by telephone.

*****

517. These rules do not modify or supersede any rule of the Rules and Regulations of the Operating Department, or Special Instructions Supplementary Thereto.

AIR BRAKE RULES AND REGULATIONS

Governing

Train Handling, Operation and Tests of Air and Air Signal Apparatus

*****

Emergency Application:

440. When the brakes apply automatically from the train at an emergency rate of reduction, as shown by the brake pipe pressure falling rapidly to zero, the automatic brake valve must be placed in lap position to prevent loss of main reservoir pressure, and left in that position until the train stops. Use sand until train stops. Use the independent brake to reduce brake cylinder pressure on the engine to prevent sliding wheels. Use the engine brake as heavily as possible without sliding drivers, for the last 100 feet with a freight train to avoid a run-out of any slack as the train stops.

When stop is completed (and PC switch recovered on a diesel engine), allow sufficient air to pass through the brake pipe to enable the trainmen to locate the cause.

(a) When the brakes apply automatically from the train at an emergency rate of reduction, the throttle (if open) should be gradually closed. If speed of train increases considerably with throttle open, it may be due to train parting near head end. Under this condition the throttle should not be closed while there is danger of rear portion of train colliding with front portion.

(b) When brakes apply at an emergency rate of reduction on a train assisted by engines in the rear, the assisting engineman should immediately close throttle, apply sand and not reduce engine brake cylinder pressure unless there is a possibility of wheels sliding.

(c) No attempt must be made to release the brakes on a train after an emergency brake application until train has stopped, and time limit as specified in Rule 434 has been complied with.

(d) When a train is stopped with an emergency application of the brakes whether from engine or train, or at a service rate of reduction from the train, the engineman will not move the engine until signals are communicated to him hy a member of the crew. The train will not proceed without a signal from the rear in event communication is lost.

APPENDIX C

THE ALASKA RAILROAD
TRANSPORTATION

Anchorage, Alaska
March 19, 1973

OPERATING CIRCULAR NO. 9

To: All Concerned

From: Operations Officer

Subject: Observation Stops - Trains No. 5 and 6

In order to permit tourists to view Mt. McKinley and take pictures on days of clear visibility, when passenger interest warrants, Trains 5 and 6 will stop in the vicinity of Mile 224 and 279. Stops are not to exceed five minutes.

Conductors will announce these stops in advance, giving location of Mt. McKinley so passengers may prepare to take pictures.

Passengers are not to be allowed to leave the train during these stops.

/s/______________________________
Operations Officer

Distribution B, D & E

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX D

ISSUED:

Forwarded to:

Honorable Asaph H. Hall
Administrator
Federal Railroad Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-76-10 through R-76-12

On July 5, 1975, an Alaska Railroad freight train, Extra 1502 South, collided with the rear of passenger train No. 5, which had stopped just south of Hurricane, Alaska, to permit the passengers to view Mt. McKinley. All cars of the passenger train and the first four locomotive units of the freight train were derailed. Sixty-two persons were injured and one of the injured subsequently died.

No. 5 had stopped at Hurricane, 2.2 miles north of the point of the collision, and had departed at 3:41 p.m., 6 minutes later than its scheduled departure time of 3:35 p.m. The crew did not throw off lighted fusees to protect the rear of the train as it departed from Hurricane and moved southward to the mountain-viewing stop. The train had stopped for about 1 minute at the mountain stop and had just started to move southward when the collision occurred at 3:46 p.m.

The crew of Extra 1502 South had been instructed by the train dispatcher to copy a train order by radio at Hurricane. Even though the operating rules required the train to be stopped when a crewmember copied a train order, Extra 1502 South was not stopped at Hurricane.

The engineer of Extra 1502 South was copying the train order when No. 5 first became visible to the crewmembers on the locomotive, about 3,000 feet north of No. 5. The speed of Extra 1502 South at this time was 40 mph, which was in excess of the maximum permitted speed of 35 mph. The engineer applied the brakes slightly but the speed was not reduced. The train continued to move southward to about 1,500 feet north of No. 5, where the engineer applied the brakes in emergency. Then he immediately placed the independent brake value in the full-application position and depressed the release bail. This action released the emergency application of the

brakes on the five locomotive units. The lead locomotive unit of Extra 1502 South had a 24 RL braking system which permits an automatic brake application on the locomotive to be released by depressing the independent brake value handle in any position.

This accident appears to be the culmination of a series of rule violations and poor practices. There is no doubt that the engineer and front brakeman of Extra 1502 South saw No. 5 in sufficient time to have stopped their train by regular means, despite its improper speed, but the preoccupation of the engineer with copying the train order permitted the train to move to a point where an emergency application was required to stop the train short of the collision. The emergency application still should have stopped the train short of the collision, but the improper release of the locomotive emergency brake negated this possibility.

Therefore, the National Transportation Safety Board recommends that the Federal Railroad Administration;

1. Institute procedures on the Alaska Railroad to insure consistent compliance with operating rules. (R-76-10)(Class II, Priority Followup)

2. Revise the Alaska Railroad operating rules so that they explicitly state the actions required to provide safe operation. (R-76-11)(Class II, Priority Followup)

3. Require all railroads to modify the 24 RL independent brake valves to eliminate future unwanted release of locomotive brakes. (R-76-12)(Class II, Priority Followup)

TODD, Chairman, McADAMS, THAYER, BURGESS, and HALEY, Members, concurred in the above recommendations.

By: Webster B. Todd, Jr.
Chairman

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

REAR END COLLISION OF THREE MASSACHUSETTS BAY TRANSPORTATION AUTHORITY TRAINS BOSTON, MASSACHUSETTS AUGUST 1, 1975

REPORT NUMBER: NTSB-RAR-76-5

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-RAR-76-5	2. Government Accession No.	3. Recipient's Catalog No.
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		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Surface Transportation Safety Washington, D. C. 20594		10. Work Unit No. 1789
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 2059		13. Type of Report and Period Covered Railroad Accident Report August 1, 1975
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract On August 1, 1975, during the evening rush hour, southbound traffic on the Red Line of the Massachusetts Bay Transportation Authority in Boston backed up because of a train standing at a stop signal in the tunnel south of Charles Street Station. Train 1402, a four-car "Bluebird" train, stopped at signal 236 because of the backup. Train 1604, a four-car "Silverbird" train, was keyed by signal 234 and crashed into 1402 about 4:58 p.m. About 3 minutes later, a four-car "Bluebird" train, 1431, crashed into the rear of train 1604. One hundred and fifty-four persons were injured; total damage to equipment was estimated to be $425,000.

The National Transportation Safety Board determines that the probable cause of this accident was the malfunction of the train-stop tripper and the subsequent operation of trains 1604 and 1431 in violation of the rules and in excess of the speed at which they could stop short of collisions in the available sight distances.

17. Key Words Rail rapid transit; rear end collision; tripper; restricted speed; failsafe; brakes; operating rules		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.	
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FOREWORD

This report is based on an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: April 14, 1976

Rear End Collision of Three Massachusetts Bay Transportation Authority Trains Boston, Massachusetts August 1, 1975

SYNOPSIS

On August 1, 1975, during the evening rush hour, southbound traffic on the Red Line of the Massachusetts Bay Transportation Authority in Boston backed up because of a train standing at a stop signal in the tunnel south of Charles Street Station. Train 1402, a four-car "Bluebird" train, stopped at signal 236 because of the backup. Train 1604, a four-car "Silverbird" train, was keyed by signal 234 and crashed into 1402 about 4:58 p.m. About 3 minutes later, a four-car "Bluebird" train, 1431, crashed into the rear of train 1604. One hundred and fifty-four persons were injured; total damage to equipment was estimated to be $425,000.

The National Transportation Safety Board determines that the probable cause of this accident was the malfunction of the train-stop tripper and the subsequent operation of trains 1604 and 1431 in violation of the rules and in excess of the speed at which they could stop short of collisions in the available sight distances.

FACTS

The Accident

About 3:42 p.m. on August 1, 1975, a train-stop tripper malfunctioned on the Red Line of the Massachusetts Bay Transportation Authority (MBTA) between Charles Street Station and Park Street Station in Boston, Massachusetts. The malfunctioning train-stop tripper, which was on signal 234 just south of the Charles Street Station platform, caused

a southbound train, train 1625, to stop. An air leak had caused the tripper to revert to the "up" or tripping position, even though the track was clear of traffic ahead and there were no interruptions of the signal circuit. With the tripper in the "up" position, signal 234 displayed a red aspect. At that time of day, the Red Line rush hour traffic was approaching its 5 p.m. peak, when trains are operated through the area at $3\frac{1}{2}$-minute intervals.

The trains behind train 1625 also were stopped by the malfunction of signal 234, causing a traffic backup. At 4:42 p.m., the train that was behind train 1625 began to shove it down the track. The two trains stopped at Park Street Station to unload the passengers from the disabled train and then proceeded southward to clear the way for trains behind.

About 4:55 p.m., train 1402, a four-car "Bluebird" train, departed from Charles Street Station after an MBTA signalman keyed it by signal 234. It stopped at signal 236, with its rear car 458 feet south of the north portal of the tunnel that extends through downtown Boston, and remained there because signal 236 and the other signals immediately ahead were red and the motorman could see the disabled train ahead at the Park Street Station.

Train 1604, a four-car "Silverbird" train, was keyed by signal 234 after it left Charles Street Station. It proceeded around the $7^{o}12'$ curve to the right, entered the tunnel, and crashed into standing train 1402 about 4:58 p.m.

Train 1431, another four-car "Bluebird" train, also was keyed by signal 234 as it left Charles Street Station, and at 5:01 p.m. it collided with the rear of train 1604 about 179 feet inside the subway tunnel. (See Figure 1.)

When the collision occurred, the electrified third rail of the southbound track lost its power. The power was restored after power was lost, and was restored again when power was lost a second time. At 5:01 p.m., the load dispatcher shut off the power. The dispatcher was notified of the first collision by radio almost immediately, but the first notification was incomplete and did not describe the collision's circumstances. The dispatcher was notified of the second collision just after the collision occurred.

1

2

3

4

Figure 1. The motormen's views from Charles Street Station to the tunnel

Some traincrew personnel retained passengers on the disabled trains until rescue personnel arrived. Other crewmembers began to detrain passengers from the trains immediately after the collisions occurred. A northbound train on the adjacent track stopped south of the collision point. At 5:06 p.m., the motorman of that train reported to the dispatcher that passengers were on the northbound roadbed. The dispatcher advised the MBTA superintendent of night operations at 5:07 p.m. that persons were being taken off the trains. About 5:10 p.m., the superintendent arrived at the accident site, and at 5:11 p.m., he ordered that the power be shut off on the northbound track.

The Boston Fire Department was notified of the emergency at 5:04 p.m. and fire department personnel arrived on scene at 5:11 p.m. No appreciable fire or smoke resulted from the collision and there was no panic. The fire department personnel began prearranged rescue operations which consisted of walking passengers to the adjacent stations and carrying out the injured with stretchers. Some minor problems were experienced because side doors of the cars could not be opened from the outside and fire department personnel could not locate enough ladders to detrain passengers quickly. The collision area was cleared of passengers in about 45 minutes and the evacuation was completed at 6:15 p.m. Of the 154 persons treated at local hospitals, 8 were admitted.

Accident Site

The trains collided on tangent track within a double-track subway tunnel. (See Figure 2.) Southward from the south end of the Charles Street Station platform, it was 39 feet to signal 234, 70 feet to the beginning of the 7° 12' curve, 485 feet to the end of the curve, 522 feet to the portal of the subway tunnel, 702 feet to the point of the second collision, 981 feet to the point of the first collision, 1,259 feet to signal 236, and 2,607 feet to the west edge of the Park Street Station platform. The first collision occurred on a descending 0.50-percent grade; the second collision occurred on a vertical curve which connected a 2.98-percent descending grade to the 0.50-percent grade. Within the subway tunnel there were walkways on the outside of each of the two tracks. The electrified third rails for both tracks were mounted between the tracks. The third rails were not equipped with protective covers. Some of the emergency lighting operated off the 600-volt direct current that supplied power to the third rail and some operated independent of the third-rail power. Fluorescent light

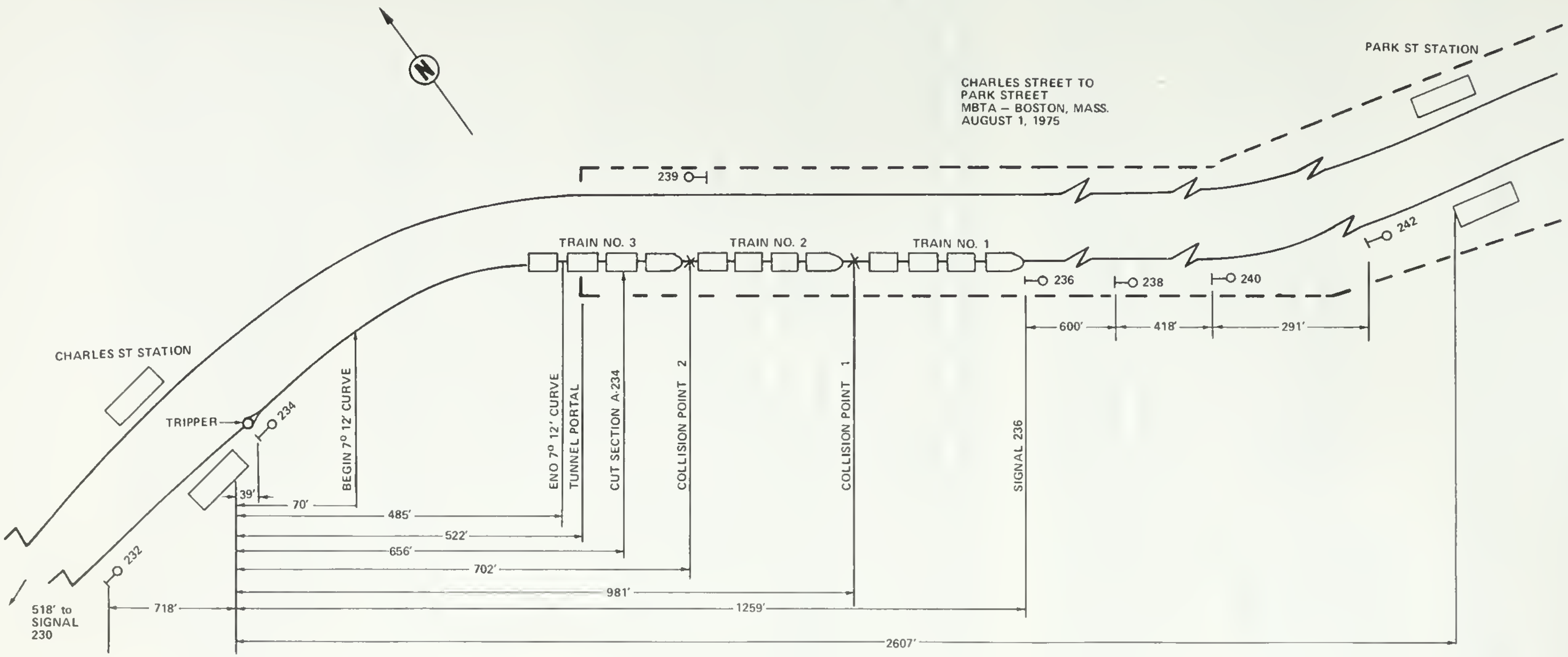

Figure 2. Accident site.

fixtures recently had been installed and were operating through this portion of the subway tunnel.

At the time of the collision, the temperature was 98°F and there were scattered clouds.

Method of Operation

General--During rush hour, four-car trains were operated by a motorman and two guards; each guard was assigned to two cars. The guard's duties were to open and close the doors at station platforms.

The destination of a train determined which of the two types of cars used on the Red Line were used in the train. In practice, this had the effect of alternating trains of "Silverbird" and "Bluebird" cars.

The speed limit through the area was 50 mph; however, trains were restricted to 35 mph around the curve between Charles Street Station and the subway tunnel.

Signal system--Trains were operated in accordance with an automatic-block signal system. There was no form of automatic train control and no cab signals were in operation on this portion of the MBTA system. The automatic block signals could display red, yellow, and green aspects. MBTA operating rules required the following for each aspect:

(1) Red - Stop and then proceed in accordance with Rule 59. (See Appendix A.)

(2) Yellow - Proceed, prepared to stop at next signal.

(3) Green - Proceed at authorized speed.

The signal system was arranged so that when one signal block was occupied by a train, at least two signals to the rear displayed red and the third signal to the rear displayed yellow. There was an exception to this arrangement in the accident area, at signal 234. When the block for signal 234 was occupied by a train, signal 234 would display red,

but signal 232 could display either red or yellow, depending on whether the train was north or south of the cut section 1/ between signals 234 and 236. If a train was south of the cut section (622 feet south of signal 234), then signal 234 would display yellow. If a train was north of the cut section and south of signal 234, then signals 234 and 232 both would display red.

All automatic block signals were equipped with train-stop trippers. The tripper was a mechanical device mounted adjacent to the rail and designed so that when a signal displayed a red aspect, the tripper would be up. The intent of the tripper was to initiate emergency braking on a train that passed a signal which displayed a red aspect. The trippers were operated by compressed air and were designed so that if the air supply was lost, the trippers would revert to the tripping or the "up" position. When the trippers were up, that particular signal displayed a red aspect regardless of the track occupancy or the signal circuit conditions in that signal block.

Under certain circumstances, the MBTA rules permitted a train to pass a signal which displayed a red aspect. (See Appendix A.) To do so without activating the trains' emergency brakes, a "key" was provided on the signal mast which, when depressed, moved the tripper to the "down" or nontripping position, and the signal would display the aspect which reflected the actual conditions for that signal block.

Certain signals had been designated absolute stop signals by the Massachusetts Department of Public Utilities (DPU). Those signals were marked by a sign reading "Rule 59A." The rules required special procedures by motormen to move trains by signals so designated. In the accident area, signals 230 and 234 were absolute signals.

Dispatchers were governed by special instructions in authorizing the movement of trains by absolute stop signals. Those special instructions prohibited the movement of trains past signal 234 until the trains ahead were clear of signal 244, south of the Park Street Station platform. (See Appendix B.)

1/ A location other than a signal where two adjoining track circuits end with a block.

Operating rules--The Safety Board obtained testimony from 15 supervisors and operating employees after the accident. The testimony and accident circumstances indicated inconsistent understanding of a number of rules pertinent to operations on August 1. The rules involved were 1(a), 40, 44(b), 51(a), the meaning of "Restricted Speed," 56(d), 56(h), 59A, 59B, 59D, 62(b)(2), 62(b)(4), 62(b)(5), 70(a), and 73(b). (See Appendix A.) The management personnel and the other employees did not interpret the rules consistently. In several cases there were different interpretations by management representatives.

Train Equipment

Both the "Bluebird" and the "Silverbird" cars were selfpropelled by 600 V direct current. The cars were 69 feet 6 inches long and the car's floors were 4 feet 1 inch high. The ends of the cars were equipped with anticlimbers operated in pairs. They were manufactured by Pullman Incorporated and had been subjected to a 200,000-pound compression test before MBTA accepted them.

The cars were equipped with two-way radios which allowed traincrew personnel to communicate directly with the dispatcher. Because different radio frequencies were used, traincrew personnel could not overhear communications from other trains; however, they could hear all communication that originated from the dispatcher or from the master control operator. Radio conversations were recorded on tape.

Both types of cars were equipped with dynamic and pneumatic braking systems which operated similarly. Service braking was accomplished by the dynamic system at speeds of 11 mph or more. Below that speed, the pneumatic air brake system provided the retardation. Emergency braking was accomplished with the pneumatic system. Both dynamic and pneumatic braking were available when the third rail was deenergized. Wheel slip/slide protection was provided for dynamic braking but not for emergency braking.

Emergency braking could be activated by persons on board the train by three methods: (1) Moving the control handle to the emergency position, (2) releasing the control handle, which activated the "dead-man" control, or (3) pulling emergency valves located in the guard's, motorman's and passengers' compartments. In addition, emergency braking could be initiated by the train-stop tripper or by a rapid depletion of the brake pipe pressure. The braking systems

were manufactured by the Westinghouse Air Brake Division of the Westinghouse Air Brake Company.

The "Bluebird" cars were manufactured in 1963. They were steel and were painted blue and white. These cars had four doorways on each side, with the centers of the end doors 9 feet 3 inches from the ends of the car. The motorman was separated from the passengers by a compartment about 6 feet long. The "Bluebird" cars had a seating capacity of 54 passengers and a maximum capacity of 308 persons. Seating was along the sides of the car, so that passengers faced perpendicular to their direction of movement. The cars weighed about 113,700 pounds fully loaded.

The "Silverbird" cars were manufactured in 1969. They were aluminum and had three side doorways on each side with the centers of the end doors about 15 feet from the cars' ends. The motorman's compartment had similar dimensions to those of the "Bluebird." The cars had a seating capacity of 64 passengers and a maximum capacity of 239 persons. The seating arrangement was such that passengers faced either the front or the rear of the car. Seats were arranged on both sides of a 2-foot 5-inch center aisle. The "Silverbird" weighed about 94,500 pounds fully loaded.

Both types of cars had two marker lights and two taillights on the rears of the cars. The markers were mounted near the top of the car and the taillights were mounted near the bottom. On the "Bluebirds," the marker lights were connected in series with the third-rail power; the taillights operated from a battery. On the "Silverbirds," all of the lights operated from a battery. The MBTA did not have performance specifications for taillights or marker lights; it depended upon the car manufacturer to provide suitable lamps.

Damage

The underframe of the last car of train 1402 (a "Bluebird") sustained plastic deformation at several symmetrically located positions along the side sills. At the end which was hit, the underframe was crushed about 8 inches and the superstructure was crushed about 19 inches, mostly near the roof. (See Figure 3.) The anticlimbers on the other three cars in train 1402 were damaged slightly but showed no other marks from the crash.

Figure 3. Crash damage to the last car of train 1403.

The right marker lights of the last car of train 1402 were demolished. The left marker light had a broken bulb and the lamp reflector and lens were smoked. The right taillight fixture was operable when power was supplied to the lamp; however, the bulb would not light. It was not determined whether the malfunctioning bulb resulted from the collision. The left taillight was operable when power was supplied.

The forward end of the first car of train 1604 (a "Silverbird") was damaged heavily. The flat face of the car was torn from the sides and pushed back into the motorman's compartment. (See Figure 4.) About 52 inches of the underframe and superstructure were destroyed. The anticlimbers between the other cars of train 1604 were damaged slightly.

When power was supplied to the rear "Silverbird" car, only the right taillight illuminated. The bulbs in the left taillight and in the right marker light were operable but the lamp fixtures were inoperable. It could not be determined whether the left marker light was operating before the collision.

The second collision caused only minor damage to the anticlimbers of the rear car of train 1604 and to the head car of train 1431.

Total damage to the equipment was estimated by MBTA to be $425,000.

Tests and Inspections

Signal system--The tests of the signals up to the collision point indicated that they displayed the intended aspects. The only malfunction discovered was a small hole in the air hose which controlled the operation of the train-stop tripper at signal 234. The hole resulted in the air leak which had caused the tripper to rise. When the tripper key on the signal was operated, the tripper went down, but it slowly reverted to the "up" position as the air escaped.

The records of signal work performed in the area showed that two signalmen had been called at 4 p.m. on August 1, 1975, because signal 234 was "holding red." At 9 a.m. the previous day, another signalman had been called to the same location for the same reason. The cause of delay that day was reported to have been a malfunctioning tripper caused by a loose connection on the tripper's air hose. The signalman had tightened the connection.

Figure 4. Crash damage to forward end of the first car of train 1604.

Visibility tests--Tests were made to determine the locations where the rears of trains 1402 and 1604 first should have become visible to motormen in approaching trains. Because the accident circumstances involved moving from daylight to an artifically lighted tunnel, the tests were made on an afternoon when the sun's position was similar to that on the day of the accident.

The rear of a "Bluebird" train, parked where the rear of train 1402 was standing on August 1, first became visible 490 feet north of the rear of the "Bluebird," or 40 feet north of the tunnel portal. The rear of the "Silverbird" train first became visible 266 feet north of the rear of the "Silverbird," or 96 feet north of the tunnel portal. In both instances, the first features perceived by a man looking for a train were the taillights and marker lights; however, shortly after he saw the lights, he could see the trains themselves because of the tunnel's fluorescent lighting.

Braking--On August 4, the brakes of the cars were tested at Eliot Carhouse, Harvard Square, Cambridge. The brakeshoes applied and released properly on all cars tested except on the right side of No. 1 wheel and the left side of No. 3 wheel on car 1431. Loose brakeshoes caused that malfunction.

On August 9, running brake tests were made on the two trains which struck the other trains. Car 1634 replaced the damaged car 1604. Between Charles and Park Streets, markers were placed at the spots where the motorman of the first colliding train first perceived the rear of a "Bluebird" train standing at signal 236. The distance between the markers and the rear of the train was 460.6 feet. (Table 1 shows the speeds and stopping distances of train 1634 in the tests. Table 2 shows the results of brake tests using "Silverbird" cars 01431-01426-01486-01441.)

Between Charles and Park Streets, a marker was placed at the point from which the motorman could see the rear of the "Silverbird" involved in the collision. The distance was 293.2 feet. At 8 mph, the train traveled 27 feet in the emergency mode and 22.4 feet in the maximum brake mode. At 28 mph, it traveled 399.6 feet in the emergency mode and 306.2 feet in the maximum brake mode.

On August 28, additional tests were made using "Silverbird" cars 01607-01606-01649-01648. (See tables 3 and 4.)

TABLE 1

STOPPING DISTANCE TESTS
BETWEEN CHARLES & PARK STREETS
AUGUST 9, 1975

SILVERBIRD CARS 01634-01605-01609-01608

SPEED (MPH)	BRAKING MODE	STOPPING DISTANCE (FEET)
6	Maximum Brake	24.4
6	Emergency	28.1
10	Maximum Brake	64.1
15	Maximum Brake	77.9
15	Emergency	115.1
25	Maximum Brake	184.1
25	Emergency	245.6
35	Maximum Brake	315.3
35	Emergency	523.3

TABLE 2

STOPPING DISTANCE TESTS
BETWEEN CENTRAL AND KENDALL SQUARES
AUGUST 9, 1975

BLUEBIRD CARS 01431-01426-01486-01441

SPEED (MPH)	BRAKING MODE	STOPPING DISTANCE (FEET)
6	Maximum Brake	24.7
6	Emergency	24.0
10	Maximum Brake	61.7
10	Emergency	58.3
20	Maximum Brake	152.0
20	Emergency	183.4
30	Maximum Brake	252.3
30	Emergency	333.1
45	Maximum Brake	621.0
45	Emergency	752.8

TABLE 3

STOPPING DISTANCE TESTS
AUGUST 28, 1975

SILVERBIRD CARS 1607-1606-1649-1648

Speed (mph)	Braking Mode	Stopping Distance (ft)	Stopping Time (sec)	Deceleration Rate (mph/sec)
Between Kendall & Central				
7	Service	28' 11"	4	1.7
6	Emergency	17' 6"	3	2.0
22	Service	141' 9"	7.7	2.8
20	Emergency	141' 1"	7.0	2.9
25	Service	197' 8"	9.0	2.8
26	Emergency	175' 7"	7.1	3.6
34	Service	313' 5"	11.5	2.9
34	Emergency	291' 9"	10.0	3.4
44	Service	582' 6"	16.0	2.8
45	Emergency	502' 4"	13.0	3.5
At Accident Site				
8	Service	36' 3"	4.5	1.8
7	Emergency	18' 1"	3.0	2.3
16	Service	107' 8"	7.5	2.1
15	Emergency	103' 8"	6.5	2.6
27	Service	290' 10"	12.25	2.2
26	Emergency	242' 11"	10.0	2.6
35	Service	482' 5"	15.0	2.3
35	Emergency	453' 11"	14.0	2.5

TABLE 4

BRAKE CYLINDER PRESSURES

Specifications:

Full Service	- 32-33	psi
Emergency	- 38	psi

Car 1607

Full Service	- 45	psi
Emergency	- 55	psi

Car 1606

Full Service	- $33\frac{1}{2}$	psi
Emergency	- 35	psi

Car 1649

Full Service	- $42\frac{1}{2}$	psi
Emergency	-100	psi

Car 1648

Full Service	- $32\frac{1}{2}$	psi
Emergency	- $38\frac{1}{2}$	psi

Impact speed--The U.S. Department of Transportation (DOT) Transportation Systems Center (TSC), Cambridge, Massachusetts, conducted energy calculations to estimate the impact speeds. TSC equated the kinetic energy of the moving train to the energy dissipated through structural damage and sliding of the cars involved; it assumed that there were 100 passengers in each car and that the first "Bluebird" train had slid 60 feet with the brakes fully applied.

Assuming various combinations of train sliding distances from the first and second collisions, TSC concluded that train 1604 struck the rear of train 1402 at about 28 mph and train 1431 struck the rear of train 1604 at less than 8 mph.

MBTA investigation--A six-man committee investigated the accident and issued a report on October 3, 1975. The report included recommendations directed to employees involved in the accident. (See Appendix C.)

ANALYSIS

Operations

Several faults allowed these collisions to occur. First, operating employees did not comply with procedures for advancing trains past stop signals. Second, once past signal 234, the motormen of the striking trains did not comply with the requirements of restricted speed. Third, the employees who keyed the trains by signal 234 without consulting the dispatcher violated Rule 59A. Fourth, the motormen who passed signal 234--a 59A signal--without first sending a trainman ahead to insure that the block was clear also violated Rule 59A.

In spite of the violations of Rule 59A, the collisions could have been avoided if the motormen had complied with the restricted speed requirements. The only requirement of the restricted speed rule that is completely enforceable is the maximum speed of 6 mph.

Poor judgment which results in a motorman's running too fast within the limits of the maximum authorized speed is hazardous, but when a motorman exceeds the maximum authorized speed, the infraction cannot be considered an error in judgment. In this accident, if

the motormen had operated the striking trains at less than 6 mph, the collisions could have been avoided.

The actions of the master control operator and of the dispatcher, who allowed the master control operator to authorize trains to key by signal 234 without ascertaining that the train ahead had cleared signal 244 at Park Street Station, were not in compliance with Rule 59 and were contributing factors to the accident.

It appears that the MBTA's rules and special instructions contemplated such situations as those on August 1 and were designed to prevent accidents under those circumstances. However, the large number of persons who failed to comply with the pertinent rules in this case suggests that either the rules and instructions were deficient or enforcement was lax.

The employees, in their statements, did not give clear and consistent interpretations of the rules. It could not be determined whether this was because of inadequate training, inadequate dissemination of the rules and special notices, or insufficient supervision to insure complete and consistent compliance with the rules. The dispatcher's failure to insist on compliance with Rule 59A was an instance of inadequate supervision. The rules and special notices had been disseminated to the employees.

The inconsistent interpretations and understandings of rules by the various classes of employees suggest an institutional problem. To have consistent application of and compliance with operating rules requires consistent interpretations of the rules by management and operating personnel. These interpretations must be disseminated to all employees so that the rules can be enforced, and then they should be enforced consistently.

Visibility

Even though there was significant contrast between the light in the tunnel and the light just outside it, the car could be perceived easily. The operability of the taillights before the accident could not be determined. However, the standing train 1402 could be perceived, even without taillights and marker lights, soon enough for the following train to have stopped short of it at the authorized speed of 6 mph.

Brakes

The trains in the tests on August 1 stopped quicker in the maximum braking mode than in the emergency mode. Because of this the MBTA, at the request of the Safety Board, ran additional tests on August 28. In those tests the trains stopped quicker in the emergency mode than in the maximum brake mode. The brake cylinder pressures were found to be significantly higher than those called for by MBTA maintenance specifications.

The MBTA's cars have a braking system similar to those found on other transit cars throughout the country. The Safety Board has not determined the exact cause for the erratic braking behavior; however, the malfunctions could be a significant hazard. Therefore, on September 19, 1975, the Safety Board made recommendations to the Federal Railroad Administration (FRA) to require correction of the problem in the MBTA cars and to determine whether the problem exists in other cars. MBTA has given the problem of the erratic braking behavior the same priority as has the Safety Board and is conducting continuing tests.

Fail-Safe Design of Tripper

The events in this accident support a recommendation which was made by the Safety Board in a report entitled "Safety Methodology in Rail Rapid Transit System Development" [2/] regarding the inadequacy of the fail-safe concept in the design of modern rapid transit systems. (The fail-safe concept is to design systems so that if the system fails, the safety of the system will be unaffected or will be converted to a state in which no injury or damage can result.)

When a system is designed using the fail-safe concept and the system stops as a result of any failure, no matter how insignificant, the tendency of operators is to nullify the failures by hardware changes not anticipated by the original fail-safe design or to overcome the effects of the failure by disregarding the rules which are designed to make the system safe. In this case, the employees violated rules when they bypassed the malfunctioning tripper, and the collision resulted.

The Safety Board's investigation of this accident did not analyze the MBTA system sufficiently to conclude whether the design of the

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2/ "Safety Methodology in Rail Rapid Transit System Development," August 8, 1973. NTSB-RSS-73-1.

fail-safe system, which had a tripper that was designed to fail-safe in the "stop" position, was the safest system design. However, the fact that the failure initiated the chain of events that resulted in the accident illustrates the point that the "fail-safe" concept may not produce safe overall operation. This is particularly evident in this case where the interaction between the man and machine components of the system were not managed effectively.

Another recent accident involving a Metroliner on the Penn Central had similar causal factors. A safety device malfunctioned and stopped the Metroliner; a following train, which had legitimately passed a signal, struck the Metroliner. The following train was exceeding the maximum speed while operating under the restricted speed rule.

CONCLUSIONS

1. The dispatcher, the master control operator, the employees who keyed the trains by signal 234, and the motormen of the striking trains violated pertinent operating rules.

2. The maximum speed of 6 mph is the only clearly defined and enforceable requirement of the restricted speed rule.

3. If the motormen had operated the striking trains at 6 mph or less, they could have stopped their trains short of the collision.

4. The brakes on the trains were capable of stopping the trains in the sight distance available if the trains had been operating at 6 mph or less.

5. At 6 mph, the motormen operating the following trains could have seen the standing train in time to stop.

6. It could not be determined why the employees violated the rules. The most probable reason is insufficient training and supervision.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the malfunction of the train-stop tripper and the subsequent operation of trains 1604 and 1431 in violation of the rules and in excess of the speed at which they could stop short of collisions in the available sight distances.

RECOMMENDATIONS

As a result of its investigation of this accident, the Safety Board has issued the following recommendations to the Federal Railroad Administration:

> Require the Massachusetts Bay Transportation Authority to insure, immediately, that all of its rail rapid transit cars are capable of the deceleration specified in their designs for emergency braking.
>
> Require the Massachusetts Bay Transportation Authority to check periodically to insure that the specified emergency braking capability is maintained.
>
> Determine whether this problem of inadequate emergency braking may exist in similar rapid transit cars in other parts of the country and take whatever corrective action is necessary.
>
> Insure that the MBTA implements the recommendations made by its investigating committee.

On October 3, 1975, the MBTA released the report of the MBTA investigating committee which investigated this accident. The Safety Board concurs in the committee's recommendations and has issued the following recommendation to the Massachusetts Bay Transportation Authority:

> Implement the recommendations made by the MBTA investigating committee.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

PHILIP A. HOGUE, Member, did not participate in the adoption of this report.

April 14, 1976

APPENDIX A

EXCERPTS FROM RULES FOR TRAINMEN AND OTHER EMPLOYEES OF THE RAPID TRANSIT LINES OF MBTA

1. KNOWLEDGE OF RULES

(a) All employees whose duties are prescribed by these rules will be furnished with a copy of them.

40. CONDITION OF PASSENGER VEHICLE

Employees must determine that the vehicles in their charge are in proper condition for service at all times.

44. FAILURE OF POWER

(b) Employees must never leave their respective places nor allow passengers to disembark when a failure of power occurs, except when it is absolutely necessary.

41. SAFETY OF PASSENGERS

(a) The safety of passengers is our first consideration. All employees are required to exercise constant care to prevent injury to persons or property and in all cases of doubt to take the safer course.

"RESTRICTED SPEED":

Proceed, prepared to stop short of a car, train or other obstruction and watch for broken rail or switch not properly lined, not exceeding six (6) miles per hour.

56. HAND, FLAG, AND LANTERN SIGNALS AND SAFETY CONES

(d) Moving the hand, flag or lighted lantern up and down means PROCEED. A red flag or lighted red lantern must NEVER be used to give the PROCEED SIGNAL.

(h) Employees engaged in flagging work must provide themselves with a whistle and the proper flags or lighted lanterns for signalling, use the whistle to warn crews of approaching trains and use the flags or lanterns for the signalling required.

59. FLAGGING BY SIGNALS

A. Should a train with a straight roadbed ahead be held by a block signal displaying a RED ASPECT, or by an imperfectly displayed signal, or by the absence of a signal at a point where a signal is usually displayed, any of these conditions must be regarded as an indication of danger. After stopping for one (1) minute the Motorman must send a Trainman to such signal to depress the automatic trip stop by means of the key provided for that purpose. After insuring that the roadbed ahead is clear, the Motorman shall then proceed ahead at RESTRICTED SPEED (no more than six (6) miles an hour) to the next signal, prepared to stop short of a train or any other obstruction in that block and keeping a close observation for a broken rail, a switch not properly lined, or for any other defect.

If a train is held by a block signal displaying a RED ASPECT, or by an imperfectly displayed signal, or by the absence of a signal at a point where a signal is usually displayed and the roadbed ahead is curved, any of these conditions must be regarded as an indication of danger and the Motorman must, after one (1) minute, send a Trainman ahead to a point where he can see the second block signal ahead of the train, and upon determining that that block is clear, return to the first block signal and depress the automatic trip stop by means of the key provided. After insuring that the roadbed ahead is clear, the Motorman shall then proceed ahead at RESTRICTED SPEED (no more than six (6) miles an hour) to the next signal, prepared to stop short of a train or any other obstruction in that block and keeping a close observation for a broken rail, a switch not properly lined, or for any other defect.

Upon orders of an official or during adverse weather condition (meaning observed snow, sleet, or freezing rain or the indication of adverse weather given by an illuminated sign flashing the word "SNOW"), if a train is held by a block signal displaying a RED ASPECT or by an imperfectly displayed signal, or by the absence of a signal where a signal is usually displayed, and the signal involved has attached to its staff a signed marked "RULE 59A," a dangerous condition is likewise indicated and the Motorman must keep the train stopped for two (2) minutes, then send a Trainman to the nearest telephone, and the Trainman must contact the DISPATCHER on Line 6-221 for orders. When orders to proceed have been received by the Trainman or other authorized employee from the Dispatcher, the Trainman will depress the automatic trip stop by means of the key provided for this purpose at the signal. After insuring that the road-bed ahead is clear, the Motorman shall proceed ahead at RESTRICTED SPEED (no more than six (6) miles an hour) to the next signal, prepared to stop short of a train or any other obstruction in the block and keeping a close observation for a broken rail, a switch not properly lined, or for any other defect.

ADDENDUM #1 TO RULE 59, PARAGRAPH A. FLAGGING BY SIGNALS

If a train is held by a block signal displaying a RED ASPECT due to a train occupying the block ahead, after one minute the motorman must send a trainman ahead to determine the problem and request instructions for his motorman.

Motorman must not enter the occupied block unless specifically instructed that it is safe to do so by his trainman who has received orders from the official at the scene, or from the traincrew of the train occupying the block ahead. The trainman will then return to the first block signal, and after instructing the motorman, the trainman will depress the automatic trip-stop by means of the key provided. Motorman may then enter the occupied block at a restricted speed (6 MPH).

APPENDIX A

59\. B. Upon finding a block or interlocking signal attended by an employee detailed to flag trains past it, the motorman must bring train to a full stop before passing signal. After flagman at the signal has caused the automatic trip stop to be keyed down and has given the necessary signal, the motorman shall then proceed at restricted speed. Automatic trip stops must never be left hooked down. <u>If, for any reason, a signal is not working properly, the Train Dispatcher must be notified immediately.</u>

59\. D. Employees sent out to flag trains by signals in daylight must be equipped with one yellow flag and one red flag, and, during darkness or in subways and tunnels at any time, with one yellow lighted lantern and one red lighted lantern, and must wear required safety belts or vest.

62\. CARE OF TRAIN

(b) Lights

(2) The Motorman is responsible for the proper display of the head lights and markers.

(4) Marker lights at the front and rear of train must be illuminated and display a red aspect, except when otherwise specified.

(5) The rear Guard is responsible to see that the rear of train is properly lighted.

70\. EMERGENCY VALVE

(a) An emergency valve is located at Guard's position and in Motorman's cab on all cars and must be used by Trainmen to stop train in case of emergency.

APPENDIX A

73. UNUSUAL STOPS

(b) Trainmen must not depend on block or interlocking signals to protect a train when stalled in an obscure place, but a flagman must be sent back a distance of a least 300 feet and more, if necessary, to protect such a train.

APPENDIX B

EXCERPT FROM SPECIAL INSTRUCTIONS SIGNED BY T. J. FALLON, SUPERINTENDENT, RAIL LINES, DECEMBER 31, 1968

DISPATCHERS

INSTRUCTIONS AND LOCATIONS OF ABSOLUTE SIGNALS

DISPATCHER - When receiving a call from a trainman whose train is held at an absolute signal, the Dispatcher must ascertain the location of the train ahead of said signal before issuing orders to the trainman to key by said signal and to proceed at a restricted speed.

The following is a list of absolute signals, locations and clearance areas:

CAMBRIDGE-DORCHESTER

Eastbound-Route 031

Signal #234, Charles St. Station - Train ahead must have cleared signal #244, Park under Station.

APPENDIX C

CONCLUSIONS AND RECOMMENDATIONS OF MASSACHUSETTS BAY TRANSPORTATION AUTHORITY INVESTIGATING COMMITTEE

CONCLUSIONS AND RECOMMENDATIONS

1.) DISPATCHER

The Central Control Dispatcher disregarded operating procedures as required in various areas:

a) Did not notify Signal Division of malfunction of Signal 234 (59A) when first notified.

b) Allowed the Master Control Operator to give orders to key by Signal 234 (59A) without checking ahead. (Rule 59 infraction.)

c) Waited five minutes before cutting off third rail power.

d) Did not answer requests by Trainmen to unload trains.

e) Disregarded his responsibilities by allowing other employees to make critical decisions without actively supervising or participating in the decisions.

f) P.A. System at Central Control could have been put to better use.

RECOMMENDATIONS

1) Every Dispatcher attend training school for instructions pertaining to operating rules, equipment and emergency procedures at least once every year.

2) Outline and define the authority and responsibility of the Dispatcher.

APPENDIX C

3) A bulletin board should be installed in the Control Center for the periodic posting of special orders with lettering across the top stating "All Central Control operating personnel are to review posting on this bulletin board daily."

The Chief Dispatcher should be responsible for keeping a loose leaf folder of all special orders in sequential order. The Director of Transportation should review and reissue all special orders on a yearly basis.

4) Change the Chief Dispatcher's duties so that he does not act as a regular Dispatcher, but actively supervises the operation of Central Control during peak hours.

2.) MASTER CONTROL OPERATOR

a) Did not know operating rules as required; namely, Rule 59 and radio communication procedures.

b) Made decisions that were not his responsibility.

RECOMMENDATION

1) All Master Control Operators to be instructed on a yearly basis on operating rules, procedures and radio communications.

3.) TRAIN STARTER

a) Did not relieve injured Motorman at Harvard.

b) Announced on radio to have trip hooked down in spite of Rule 59.

c) Removed Inspector from flagging trains by Signal 234 to relieve Motorman.

RECOMMENDATION

1) All Train Starters attend the Training School at least once a year. Training to cover operating rules, equipment and emergency procedures.

APPENDIX C

4.) INSPECTORS

a) Did not follow Rule 59 as required.

RECOMMENDATION

1) All starters and Inspectors attend Training School on yearly basis. Instruction to cover operating rules, equipment and emergency procedures.

2) Inspectors and Starters should periodically check Rapid Transit personnel, particularly Motormen, on their knowledge of operating rules and procedures and to step up monitoring of employee performance.

5.) MOTORMEN

As previously stated, both Motormen violated Rules 55, 59 and 78.

a) Tests indicated that Motormen exceeded 6 MPH, after going by Signal 234.

b) Tapes indicate other Motormen were in violation of Rule 59.

RECOMMENDATION

1) Re-instruct all Motormen on equipment, operating rules and emergency procedures on an annual basis. The importance of Rule 59, as well as other similar critical rules, to be stressed.

6.) GUARDS

a) Actions of Guards during the evacuation procedure indicates they performed as instructed.

RECOMMENDATION

1) The yearly re-instruction program for Guards to be continued.

APPENDIX C

7.) SIGNAL MAINTAINERS

a) Did not follow operating procedures for flagging by signals as required.

b) Should not have keyed trains by Signal 234.

RECOMMENDATIONS

1) The Training Department to thoroughly instruct all present and new Signal Maintainers regarding flagging and operating rules and procedures. Re-instruction to occur yearly.

2) Signal Maintainers hours be changed to 7:00A-3:00P, 3:00P-11:00P and 11:00P-7:00A, in order to provide better coverage during the peak hours.

3) That second Maintainer required on signal problems in the subway and on structures be substituted by a Flagman from Transportation Department.

4) Signal Division Clerk should immediately record the actual time a call for defective signal is received.

OTHER RECOMMENDATIONS

8.) COMMUNICATIONS

a) There are reports of poor reception and transmission to and from Charles-M.G.H.

b) After reviewing the radio tapes, it is evident to the Committee that the employees using the radio communications demonstrated poor radio communication techniques.

RECOMMENDATIONS

1) An attenuation and propagation test should be conducted under the auspices of the Communications Section of the Signal and Communications Division and resulting recommendations be implemented.

2) A video tape should be prepared by the Communications Section of the Signal and Communications Division for use by the Training Department of the Safety and Training Directorate in training all personnel involved in the use of radio communications.

9.) CAR SIDE DOORS

a) Inability to open the side doors of rapid transit car from the outside was a problem and helped slow evacuation.

RECOMMENDATION

1) A study be made by the Maintenance, Transportation and Safety and Training Directorates to determine the feasibility of providing a means of opening side doors from outside the cars.

10.) RULE CHANGES - RECOMMENDATIONS

1) Immediately review and up-date rule books, especially signal rules to insure a clear interpretation.

2) Change sign that is located near the key release on 59A signals to read.....

> "DO NOT KEY BY THIS SIGNAL UNTIL ORDERS ARE RECEIVED FROM THE DISPATCHER. VIOLATORS SUBJECT TO DISCIPLINE."

3) Inspectors and Starters duties and responsibilities should be outlined in the rule book.

11.) TRAINING FOR NEW INSPECTORS AND STARTERS

Written examinations for new Inspectors and Starters should be controlled by the Director of Safety and Training and not the Personnel Department. Results of these examinations should be sent to the Director of Transportation for his review and selection of employees for these positions.

APPENDIX C

In addition to the on-the-job training at locations in the districts, two days should be spent in the Training School for instructions on duties, rules, locations, overcoming train troubles and emergency procedures.

12.) SAFETY AND TRAINING

a) The training of Dispatchers, Train Starters, Master Control Operators and Signal Maintainers is not the responsibility of the Safety and Training Department.

b) Poor distribution of various rule books to Maintenance personnel pertaining to Rapid Transit operations.

c) Should be authorized to take a stronger approach in pursuing these other departments for the training of their employees on safety and operational procedures.

d) Insufficient coordination between Safety and Training and other departments in up-dating of the rule books.

RECOMMENDATIONS

1) All Transportation personnel named above and Signal Maintainers to attend the Rapid Transit Training School for instructions on operating rules and emergency procedures before working in the above classifications.

2) Safety and Training to promptly insure proper distribution of up-dated rule books and to give instructions to employees.

3) Safety and Training to take a stronger approach in requiring other departments to provide employees for training in safety and operational procedures.

4) Safety and Training to consult with other departments on rule changes and the issuance of rule changes.

5) Safety and Training to develop a process whereby rule books are thoroughly reviewed and up-dated. This process is to involve the Transportation, Maintenance and Personnel Directorates.

NATIONAL TRANSPORTATION SAFETY BOARD
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RAILROAD ACCIDENT REPORT

DERAILMENT OF TANK CARS WITH SUBSEQUENT FIRE AND EXPLOSION ON CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD COMPANY

NEAR DES MOINES, IOWA

SEPTEMBER 1, 1975

REPORT NUMBER: NTSB-RAR-76-8

UNITED STATES GOVERNMENT

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15. Supplementary Notes		

16. Abstract

At 4:00 p.m. on September 1, 1975, 17 cars of a Chicago, Rock Island and Pacific Railroad train, No. 81A31, derailed at the frog of a facing point switch on the main line near Des Moines, Iowa. The train was descending a 1-percent grade on a 1-degree curve. Eleven of the derailed cars contained liquefied petroleum gas (LPG). Fire and explosions ensued; the LPG was consumed and three persons were injured.

The National Transportation Safety Board could not determine the cause of the initial derailment. The cause of the injuries and damages was the derailment of cars at or near the frog of the turnout and the subsequent tankhead punctures by disengaged couplers of the derailed tank cars.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: June 30, 1976

DERAILMENT OF TANK CARS WITH SUBSEQUENT FIRE AND EXPLOSION ON CHICAGO, ROCK ISLAND AND PACIFIC RAILROAD COMPANY, NEAR DES MOINES, IOWA SEPTEMBER 1, 1975

SYNOPSIS

At 4:00 p.m. on September 1, 1975, 17 cars of a Chicago, Rock Island and Pacific Railroad train, No. 81A31, derailed at the frog of a facing point switch on the main line near Des Moines, Iowa. The train was descending a 1-percent grade on a 1-degree curve. Eleven of the derailed cars contained liquefied petroleum gas (LPG). Fire and explosions ensued; the LPG was consumed and three persons were injured.

The National Transportation Safety Board could not determine the cause of the initial derailment. The cause of the injuries and damages was the derailment of cars at or near the frog of the turnout and the subsequent tankhead punctures by disengaged couplers of the derailed tank cars.

FACTS

The Accident

On September 1, 1975, at 10:30 a.m., a Chicago, Rock Island and Pacific Railway Company (Rock Island) freight train, No. 81A31, departed Manly, Iowa, bound for Des Moines, Iowa. The train stopped en route at Mason City and at Iowa Falls. When it departed Iowa Falls, it consisted of 2 diesel locomotives, 43 loaded cars, 18 empty cars, and a caboose. Cars 24 through 34 were tank cars which contained liquefied petroleum gas (LPG). The train was inspected routinely en route and no discrepancies were noted.

The train ascended the ruling grade on Subdivision 12 of the railroad and was descending a 1-percent grade. As the train accelerated to 25 mph in a 1-degree curve, the engineer made a 6-pound brake pipe reduction while the locomotive units were operating at maximum capacity.

About 4:00 p.m., as either the rear truck of car 26 or the lead truck of car 27 traversed the frog of a left-hand turnout, the car derailed toward the east. The engineer noted a "tugging and jerking" in the locomotive. A trainman on the lead locomotive unit looked back and saw dense

vapors as the coupler of car 28 penetrated the trailing end of car 29. The head brakeman and other witnesses saw fire almost immediately after the initial derailment. An additional tankhead was punctured. The first of several explosions occurred about 9 minutes after the initial derailment. Parts of three tanks rocketed; three exploded and formed flat sheets and others continued to burn. The conductor radioed the Rock Island dispatcher at Des Moines of the derailment and fire.

Postaccident Activities

Local rescue units responded immediately. Firemen arrived at the scene after the first explosion and began to set up equipment and connect hoses to a water supply. At this time, the firemen did not know what was burning. A second explosion occurred as the firemen approached the tank cars but before they were within range of the explosion. As a result of this explosion, they decided not to fight the fire. After the firemen had retreated, another tank car exploded and cast fragements into a nearby storage facility of LPG. Firemen from surrounding fire departments arrived to assist the local firefighters. One of these departments attempted to fight the fires, but was ordered out of the area.

About 15 minutes after the train derailed, the Iowa State Fire Marshall observed the area from a helicopter and ordered that it be evacuated. Pedestrians and bystanders were removed from the area, businesses and homes were evacuated, and traffic over Interstate 80 was rerouted. The area was declared safe for reentry on September 5 -- 4 days after the accident.

An estimated 300,000 gallons of LPG were consumed in the fire and the explosions. Monetary loss was estimated at $834,000.

Accident Site

The first cars derailed at milepost (M.P.) 77.9 at a No. 10 frog of a left-hand turnout. The major fire and explosions occurred just beyond the highway bridge which carried Interstate Highways 80 and 35 over the railroad. (See Figure 1.) At M.P. 78.6, southbound trains begin to descend 2 miles of a 1-percent grade; the 2 miles extend through the 5,900-foot, 1-degree curve on which the cars derailed.

The track structure consisted of chats ballast applied in 1952 and crushed stone recently applied to correct the surface. Treated, fully-plated crossties with four track spikes per crosstie were renewed in 1970 at the rate of 1,000 crossties per mile. The 112-pound rail, which was rolled and laid in 1937, was jointed with 4-hole, 24-inch angle bars and 1-inch-diameter track bolts, and was box-anchored with 8 rail anchors per rail. A 30-mph speed restriction in the accident area had been in effect since 1974 because of ballast and surface conditions. The track was rated as FRA Class 3.

Figure 1. Aerial view of accident site.

During the week preceeding the derailment, a track supervisor and two track foremen inspected this portion of track. During the preceding year, an FRA inspector, a general roadmaster, and a division engineer inspected the track. No uncorrected discrepancies were reported.

During the 30 days before the accident, the track was ballasted, surfaced, and lined with a Plasser tamper-liner. 1/ The maintenance was supervised by a foreman.

Trains on this line are operated by train orders, timetable, and indications of an automatic block signal system. The maximum authorized speed where the cars derailed was 30 mph.

The Train and Crew

The locomotive and caboose were equipped with operative radios. Cars 24 through 36 were 30,000-gallon DOT 112A340W and 114A340W tank cars which contained LPG. They were placarded in compliance with DOT regulations.

The crew was experienced and was qualified under current carrier's rules. They complied with the requirements of the Federal hours-of-service regulations.

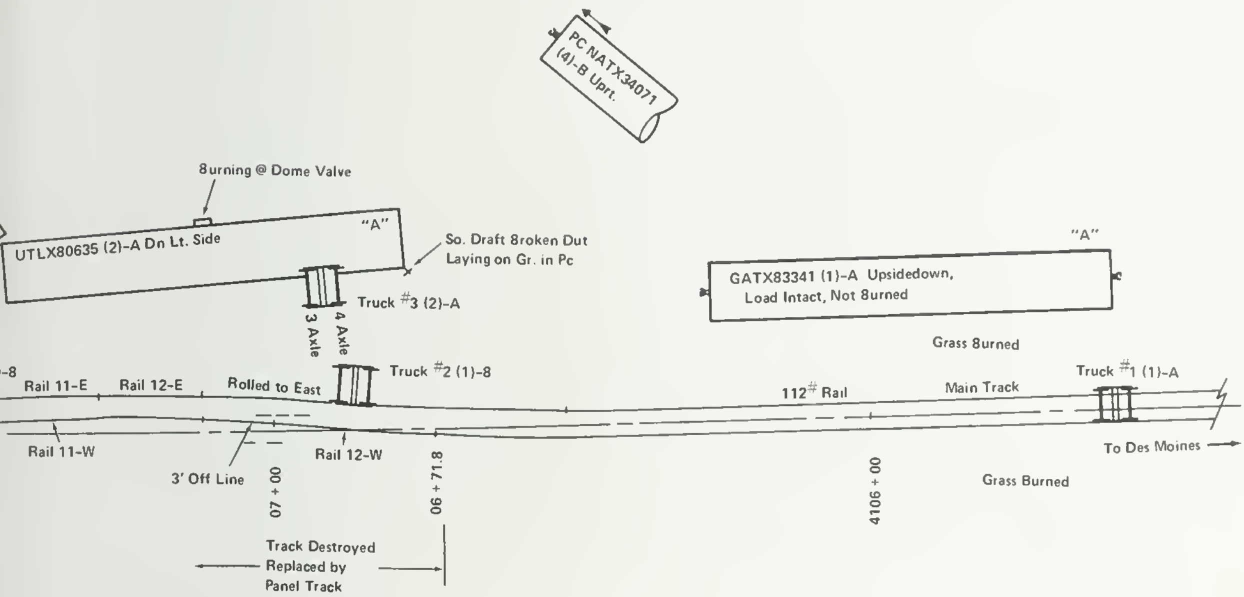
Postaccident Examinations

The switch was relatively undamaged except where the cars derailed. The main-line guardrail was found 126 ft south of its proper location, with its receiving end battered by wheels. There were wheel marks on the rail's web, south of the heel of the switch points. These were produced by the last few cars that derailed. The frog was found south of its original location. The main-line toe of the frog had a 1 1/16-inch-wide, 3/4-inch-long, 5/8-inch-deep mark, probably made by a wheel flange. A mark was also found on the north end of the frog's toe filler block. A flange mark was found on the insert of the frog at the bottom of the flangeway. The mark on the filler block was caused by a wheel set found in the vicinity of the guardrail, 127 feet south of its original location. Wheel marks on the turnout ties and rails beyond the frog indicate that some of the wheels of the first derailed cars went east on the siding.

The examination of the rails did not indicate any defects which would have caused the train to derail. The breaks in the rails were caused by the derailment. There was no evidence of track movement which could have caused the derailment.

In many instances wheel marks were traced to the wheels; however, nothing conclusive could be assigned to them. In some instances, wheel sets could not be related to the cars from which they came. (See Figure 2

1/ A tamper-liner is a mechanized device which tamps down the stone ballast under the crosstie.



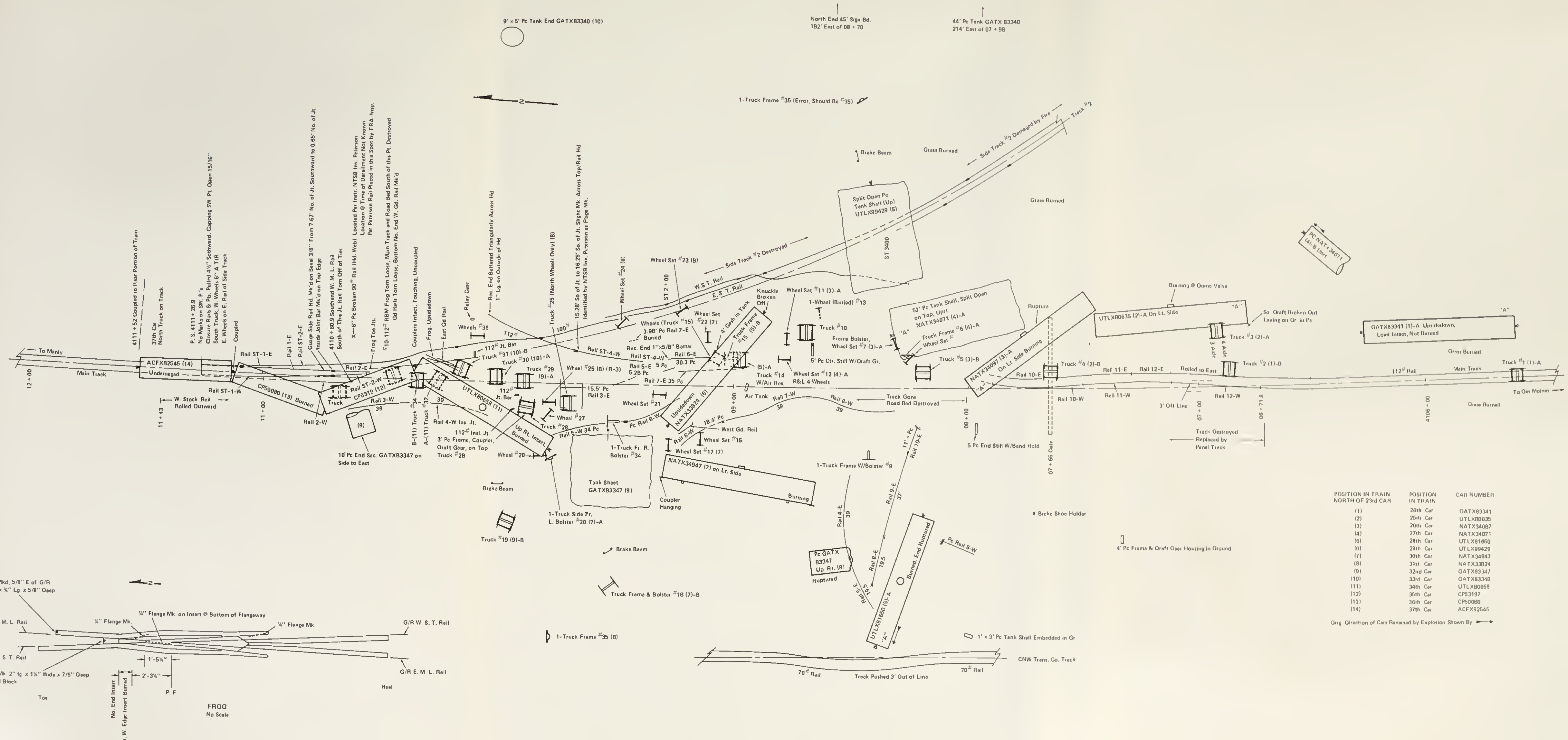
4' Pc Frame & Draft Gear Housing in Ground

POSITION IN TRAIN NORTH OF 23rd CAR	POSITION IN TRAIN	CAR NUMBER
(1)	24th Car	GATX83341
(2)	25th Car	UTLX80635
(3)	26th Car	NATX34097
(4)	27th Car	NATX34071
(5)	28th Car	UTLX81650
(6)	29th Car	UTLX99429
(7)	30th Car	NATX34947
(8)	31st Car	NATX33824
(9)	32nd Car	GATX83347
(10)	33rd Car	GATX83340
(11)	34th Car	UTLX80658
(12)	35th Car	CP53197
(13)	36th Car	CP50080
(14)	37th Car	ACFX92545

Orig. Direction of Cars Reversed by Explosion Shown By

PLAN OF ACCIDENT AREA AND LOCATION OF CAR COMPONENTS

Figure 2



POSITION IN TRAIN NORTH OF 23rd CAR	POSITION IN TRAIN	CAR NUMBER
(1)	24th Car	OATX83341
(2)	25th Car	UTLXB0035
(3)	20th Car	NATX340B7
(4)	27th Car	NATX34071
(5)	28th Car	UTLX81650
(6)	29th Car	UTLX99429
(7)	30th Car	NATX34947
(8)	31st Car	NATX33B24
(9)	32nd Car	GATX83347
(10)	33rd Car	GATX83340
(11)	34th Car	UTLXB0658
(12)	35th Car	CP53197
(13)	36th Car	CP500B0
(14)	37th Car	ACFX92545

Orig. Direction of Cars Reversed by Explosion Shown By ⟶

The running gear of the first three cars to derail showed no evidence of mechanical deficiencies. These three cars lost their trucks and appeared to have slid while overturned on their sides. The trailing truck and bolster of the third car were dragged on the track structure before the car overturned. The fourth derailed car exploded and was found in two parts. The lead end of the car consisted of about 1/4 of the car. The head was not punctured. The remainder of the tank shell was flattened by the explosion.

Coupler horns and strikers on the first four cars showed no evidence of heavy compressive forces. None of the cars were equipped with shelf couplers or tankhead shields.

The fifth car had a tankhead puncture and a brittle fracture, which produced a large hole near the center top of the trailing end. The puncture was caused when the lead coupler of the sixth car struck the tankhead. The entire fifth car rocketed several hundred feet.

ANALYSIS

The Initial Derailment

Because much of the physical evidence was destroyed by succeeding derailing cars and by the fire and explosions, it was impossible to determine which car derailed first and the exact point at which the initial derailment occurred. However, the final arrangement of cars and wheel sets supports certain hypotheses.

The final position of car 26 and the location at which its rear wheels came to rest indicate that its rear truck may have followed the side track to the left from the frog. The positions of the following car and of its lead truck indicate that the car may have taken the same route. The manner in which the right rail of the side track and left rail of the main track were bent during the derailment shows that one or more of the wheels followed a path with those two rails between the wheels. (See Figure 3.)

In order to follow such a route, the left rear wheels of car 26 or he left lead wheels of car 27 would have to follow the flangeway of the rog to the left. This could occur if the guardrail gauge is less than tandard or greater than standard; the guardrail could have become neffective if it was moved by continued impact of wheels on the flare f the receiving end or if the filler block on the receiving end was truck by something. It also could occur if train dynamics lift a wheel pward and to the left at the frog point; however, because of the heavy eight of the tank cars, it is unlikely that a wheel was lifted.

Unusual compressive forces, resulting from unequal braking in light nd heavy cars, could have contributed to the excursion of wheels to the eft of the frog point. The heavy wheel marks on the toe filler block of

Figure 3. Reconstructed track structure.

the frog and the receiving end of the guardrail were made by derailed wheels which followed the initially derailed cars. Since there were no marks of derailed wheels on crossties or rails which led to the marked filler block or the guardrail, the marks must have resulted from wheels which left the track because of a severe compressive force that caused the wheels to jump the track and subsequently strike the frog and guardrail. The bunching action behind a car or cars which had derailed at the frog could have initiated these events.

Reaction of LPG Tank Cars

The lead coupler of the sixth tank car punctured the rear head of the fifth tank car. The coupler struck an area that would have been protected if the car had been equipped with tankhead shields. Since the forces could not be computed and since data is not available regarding the resistance of the headshield to coupler impact of that description, it could not be determined whether the puncture would have been prevented by the presence of a tankhead shield alone. The same conclusion must be drawn regarding the other tankhead punctures.

If top and bottom shelf couplers had been present, they might have resisted the vertical forces which disengaged the couplers during derailment. Even if top and bottom shelf couplers had failed to resist the vertical forces, the striking forces of the couplers against the tanks would have been diminished.

If both head shields and top and bottom shelf couplers had been present, the tankhead punctures might have been prevented.

The Federal Railroad Administration (FRA) has issued a research grant to Washington University School of Engineering and Applied Science to evaluate the effectiveness of E-type top and bottom shelf couplers in the accident environment. Washington University will issue a report to FRA which will include their assessment of the effectiveness of E shelf couplers in this accident.

ire Control and Suppression

The Safety Board has investigated similar hazardous materials accidents n which the firemen were injured seriously. The firemen who responded to his accident used the same attack methods as the firemen in the previous ccidents; the only reason that these firemen were not injured was the timing f the second explosion, which occurred before the firemen were within range nd which caused them to retreat.

The firemen began to attack the fire without considering which methods ould be safest and most effective, given the hazardous materials cargo. ith the conventional firefighting methods which they planned to use, they ould not have prevented the explosions. Despite the explosions and the

nature of the cargo, one firefighting unit persisted in its attempt to extinguish the fire; this illustrates that they were not aware of the dangers of hazardous materials fires.

Officials kept everyone out of the area for 4 days, primarily because they were concerned about the danger from LPG fireballs and rocketing tank parts if the burning tank cars continued to explode. The firemen did not eliminate this danger sooner because there is no agreement as to the safest and most effective method to fight LPG fires at that stage. Also, if fire is extinguished, flammable gas could spread and explode. The use of explosive charges or projectiles to enlarge openings in burning tank cars, so that the fire will burn out more rapidly, is controversial. Until these conflicting opinions about the best methods are reconciled, firemen cannot be expected to act safely and decisively to minimize the duration of such fires.

Although the best methods to fight hazardous materials fires need to be studied further, safety knowledge has been acquired from previous accidents. The National Transportation Safety Board, the National Fire Protection Association, the Department of Transportation, and the railroads have attempted to disseminate such information to firemen. (See Appendix.) However, this accident illustrates that such information is not being disseminated effectively.

CONCLUSIONS

1. The train derailed at or near the frog of the turnout.

2. The reason that the cars derailed could not be determined.

3. There were no apparent mechanical difficulties with the train that could have caused it to derail; the reconstructed track structure demonstrated that a broken rail probably did not occur, although speed restrictions were in effect.

4. The lead coupler of the sixth tankcar punctured the rear head of the fifth tankcar; this allowed the LPG to escape, and fire and explosions ensued.

5. There are not sufficient data to determine whether head shields and top and bottom shelf couplers would have prevented the puncture of the tank heads.

6. The firefighters did not analyze what actions would have been safest and most effective before they prepared to fight the blaze.

7. The tank cars were allowed to burn for over 4 days because there was no agreement as to the best method to fight fires which involve hazardous meterials.

3. Effective channels need to be established for communication of the safety lessons learned in hazardous materials transportation accidents to all firemen who might be confronted with such emergencies in the future.

PROBABLE CAUSE

The National Transportation Safety Board could not determine the cause f the initial derailment. The cause of the injuries and damages was the erailment of cars at or near the frog of the turnout and the subsequent ankhead punctures by disengaged couplers of the derailed tank cars.

RECOMMENDATIONS

As a result of the investigation of this accident, the National ransportation Safety Board believes that it is necessary to reiterate a ecommendation to the Federal Railroad Administration:

"Determine the capabilities of top and bottom shelf couplers, head shields, and a combination of both, and issue regulations to require that DOT-112A and 114A tank cars be equipped with the best practical combination. (R-75-19)"

In addition, the Safety Board submitted the following recommendations o the Department of Commerce:

"Develop firefighting procedures which assure safety and minimize the duration of fire danger in accidents involving LPG and other compressed flammable gases in tank cars. (I-76-7) (Class II, Priority Followup)

"Establish communication with all fire services and disseminate to them specific procedures for the safe handling of railroad transportation emergencies which involve hazardous materials. (I-76-8) (Class II, Priority Followup)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

June 30, 1976

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX

ISSUED: December 27, 1971

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 13th day of December 1971.

FORWARDED TO:)
)
;tate Fire Marshals)
)
)
)

SAFETY RECOMMENDATION R-71-38

The National Transportation Safety Board issues the following nformation and warning as an advisory, pending the completion of the nvestigation and further analysis of the facts and circumstances of the erailment of Missouri Pacific Railroad Company Freight Train No. 94 at ouston, Texas, on October 19, 1971.

This freight train derailed at Houston, Texas. As the result, 16 ars piled up in the general derailment area. Included were six tank arloads of vinyl chloride, three of fuel oil, one each of acetone, butadiene, nd formaldehyde. Vinyl chloride, which escaped from a damaged 48,000-gallon ank car, ignited immediately following the initial derailment.

The Houston Fire Department responded to the scene within a few minutes fter the derailment occurred and took steps to control the fire with water. orty-five minutes after the initial derailment, a second car, containing inyl chloride, ruptured violently. This abrupt explosion and the subsequent ire resulted in fatal injury to one fireman and burns or injuries to pproximately 37 other firemen, reporters, photographers, and spectators. arge sections of a tank car were found approximately 400 feet from the derail- ent site after the explosion.

The circumstances of this accident are markedly similar to those of ne accident that occurred at Crescent City, Illinois, on June 21, 1970. At rescent City, a 15-car derailment resulted in the initial release of propane rom one of the nine cars containing this commodity. Fire ensued immediately hereafter, and fire departments responded to the scene and attempted to fight ne fire. Subsequent explosions occurred during a period ranging from pproximately 1 to 4 1/2 hours after the initial derailment. Large portions f the involved tank cars "rocketed" up to 1,700 feet from the accident site. ixty-six firemen, reporters, and photographers were injured as the result of ne subsequent explosions. A photograph of the explosion is shown in ppendix No. 2.

APPENDIX

The Safety Board has investigated other railroad accidents involving hazardous material where tank cars have exploded and rocketed. A synopsis of the pertinent details of these accidents is included as Appendix No. 1.

Generally, those accidents that have resulted in casualties to emergency service personnel or onlookers have had two distinguishing charac teristics, namely:

1. Several tank cars lay adjacent to one another in the wreckage.

2. Fire ensued, enveloped one or more tank cars, impinging upon other relatively undamaged tank cars containing hazardous materia

These accidents demonstrate that whenever a railroad accident involvi several adjacent tank cars occurs, the presence of fire substantially incre the probability of additional flareups or explosions. The reduction in property damage achieved by fire suppression methods used in past accidents has been generally insufficient compared to the risk assumed of injury and death when acting with inadequate or improper information as to the content of tank cars.

The risks, however, should be studied as closely as possible in the particular circumstances present, before initiating fire suppression effort to save the product or other property. Necessary information for this deci making process should include the rapid identification of all commodities i volved, the determination of the firefighting methods by which the risks associated with these commodities can be controlled, and whether the resour needed to cope effectively with the situation are available.

In the absence of the information necessary for an evaluation of the risks of explosion or rocketing in a fire involving several tank cars, a prudent course of action may be the complete evacuation of the area within radius of 2,000 feet. Exposure of emergency personnel to abrupt flareups o explosions can be kept to the absolute minimum by this method when no other persons or minimal property are at risk. Under no circumstances should spectators be allowed in the potential danger radius of 2,000 feet. Howeve it is not possible to give all-inclusive advice concerning the degree of risk which should be taken to fight the fire in such accidents because ther are so many variables involved. For example, there may be tank car fires i the vicinity of hospitals, schools, or other occupied premises which cannot be evacuated quickly.

Research work to correct the problem of exploding and rocketing tank cars has been underway in the Department of Transportation and the railroac industry since shortly after the accident at Laurel, Mississippi, on January 25, 1969. The problem is potentially reducible by technical change which are under study.

APPENDIX

Because the Safety Board believes the need for additional knowledge ɔr the control of tank car fires is crucial, we held a public hearing in ɔuston, Texas to gather facts concerning the derailment, fire, and ‹plosion of Missouri Pacific Train No. 94 that occurred October 19, 1971.

Therefore this information and advisory warning is issued as an .ert to the potential hazards of tank car derailments.

Reed, Chairman, Laurel, McAdams, Thayer, and Burgess Members, concurred ı the above recommendation.

John H. Reed

By: John H. Reed
Chairman

closures

APPENDIX

APPENDIX NO. 1

SYNOPSIS OF RAILROAD TANK CAR HAZARDOUS MATERIAL ACCIDENTS INVESTIGATED
by
The NATIONAL TRANSPORTATION SAFETY BOARD

Date of Accident	Location	Number of Cars in General Derailment	Number of Tank Cars Derailed	Time Between Initial Derailment and Subsequent Explosions	Contents of Tank Cars	No. of Fatalities	No. of Injuries	Types of Casualties	Distances Portions of Tank Cars "Rocketed"
Jan. 1, 1968	Dunreith, Indiana	14	6	45 Minutes	Acetone, cyanohydrin, methyl methacrylate vinyl chloride, ethylene oxide	0	5	Firemen and police	700 feet
Jan. 25, 1969	Laurel, Mississippi	15	15	Immediate	Liquefied petroleum gas	3	32	Residents	1,600 feet
Feb. 18, 1969	Crete, Nebraska	31	3	Immediate*	Anhydrous ammonia	9	53	Residents and transients	200 feet
Sept. 11, 1969	Glendora, Mississippi	15	10	5½ hours and 16 hours	Vinyl chloride and fuel additive	0	1	Power company serviceman	850 feet
June 21, 1970	Crescent City, Illinois	15	9	1 hour to 4½ hours	Propane	0	66	Firemen, reporters, photographers	1,700 feet
Oct. 19, 1971	Houston, Texas	16	12	45 Minutes	Vinyl chloride, fuel oil, acetone, buta-diene, formaldehyde	1	37	Firemen, reporters, photographers, spectators	400 feet

*No fire. Brittle fracture of tank car in crash allowed instantaneous release of entire cargo of ammonia, producing poisoning. However, similar hazard in fire exists.

APPENDIX No. 2

E losion that occurred at Crescent City, Illinois, approximately 1 hour a er initial derailment of tank cars containing propane.

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RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD

PULASKI, TENNESSEE

OCTOBER 1, 1975

REPORT NUMBER: NTSB-RAR-76-6

UNITED STATES GOVERNMENT

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15. Supplementary Notes		

16. Abstract

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The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

As a result of its investigation of this accident, the National Transportation Safety Board submitted three recommendations to the Federal Railroad Administration concerning six-wheel truck locomotives and emergency evacuation procedures.

17. Key Words Amtrak; derailment; SDP-40-F locomotive; railspread; turned-over rail; superelevation; curvature; track standards; emergency operations.		18. Distribution Statement This report is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
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FOREWORD

This report is based upon an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: May 10, 1976

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD, PULASKI, TENNESSEE OCTOBER 1, 1975

SYNOPSIS

About 12:50 p.m. on October 1, 1975, 1 locomotive unit and 11 cars of Amtrak train No. 315 derailed on the Louisville and Nashville Railroad Company's track near Pulaski, Tennessee. Of the 69 persons on the train, 31 were injured. Property and equipment damage amounted to about $1,067,000.

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

FACTS

The Accident

At 11:22 a.m. on October 1, 1975, southbound Amtrak train No. 315, which consisted of 2 locomotive units and 12 cars, left Nashville, Tennessee, en route to Florida. The train, which is called "The Floridian," operates daily between Chicago, Illinois, and Jacksonville, Florida, where it is separated; part of it continues to Miami, Florida, and the other part goes to St. Petersburg, Florida.

The train is operated over Louisville and Nashville Railroad (L&N) tracks by L&N train and engine crews between Nashville and Birmingham. On October 1, 1975, the crew consisted of an engineer, a fireman, a conductor, and a flagman. The service personnel on the train were Amtrak employees.

Between mileposts BA 256 and BA 259, a slow order, 1/ which reduced the speed limit in that area to 60 mph, was in effect. Accordingly, as No. 315 approached milepost BA 256, the engineer reduced the train's speed to 60 mph. In order to maintain this speed, the engineer maintained a slight brake application and kept the throttle in position No. 6. As the train neared the south end of a 3° 8' curve at milepost BA 258.1, the engineer felt the locomotive lurch suddenly toward the east and then toward the west. When he felt the lurches, he looked into his rearview mirror and saw that the second unit of the locomotive was bouncing and swaying. He knew that it was derailed, so he immediately applied the brakes in emergency.

The fireman also felt the lurch and looked into his rearview mirror. He saw the second locomotive unit bounce and lean slightly westward. At the same time, he saw the dining car slide slowly down the embankment on the east side of the track and the cars behind the diner follow it. Neither he nor the engineer saw the cars ahead of the diner derail and go down the west side of the embankment.

When the train stopped, the engineer immediately radioed the train dispatcher and reported the derailment. Although the dispatcher acknowledged the transmission, the engineer did not hear the acknowledgement because the transmission was interrupted momentarily. Consequently, the engineer radioed other locations so that information of the accident could be relayed to the dispatcher and to emergency forces.

The conductor and the flagman, who were not in the locomotive units, first realized that something was wrong when the cars began to derail and to roll over the embankment. When the conductor realized that his train had derailed, he radioed the engineer of the derailment.

Except for one locomotive unit and one car, the entire train derailed. Of the 69 persons on the train, 31 were injured.

Postaccident Activities

Emergency units from several communities within a 50-mile radius responded to the accident. The U.S. Army base in Fort Campbell, Kentucky, sent Medevac helicopters to assist the injured. A few of the injured were evacuated by helicopter because the accident area was not accessible by highway. The Division of Civil Defense, Military Department of Tennessee, coordinated the emergency activities. The emergency rescue units, Amtrak, and L&N personnel evacuated the injured; all occupants had been evacuated

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1/ A slow order gives a message of temporary conditions that require special operating caution, i.e., slow speed because of the track instability.

from the train within 25 to 30 minutes. The evacuation of passengers was hindered by the various positions in which the cars stopped. To reach the outside, passengers were forced to crawl over compartment partitions, through hallways with insecure foothold and handholds, and up vestibules with no prearranged handholds or footrests. (See Figure 1.) Doorway curtains hung over passageways and added to the confusion in the disarrayed interior.

Some end sliding doors had to be opened by an upward movement because the cars were lying on their sides. It was impossible to open these doors, either from the inside or the outside of the car, without mechanical assistance.

Most passengers were in the dining car at the time of the accident, and those most seriously injured during the accident were in the dining car. Passengers complained that they had been struck by loose dishes and furniture in the dining car during the derailment, and said that the furniture and the number of people in the dining car had hampered escape and rescue efforts. (See Figure 2.) The injuries to passengers consisted of broken bones, back injuries, neck injuries, cuts, and abrasions.

Figure 1. View of vestibule from bottom doors as car rests on its side, showing lack of handholds and footholds.

Figure 2. Loose and disarrayed furniture in the dining car.

The Accident Site

Train 315 derailed on a 3^{o} 8' curve to the right at milepost BA 258.1, 258.1 miles from Louisville, Kentucky. (See Figure 3.) The speed limit through the curve is 60 mph for passenger trains. The grade in the vicinity of the accident site descends southward and varies from 0.2 to 0.5 percent. The track extends through a side-hill cut to a tangent fill at the south end of the curve. The fill continues for 540 feet, after which the track enters another cut and a 3^{o} 7' curve to the right. The fill is from 35 to 40 feet high at its midpoint.

The track consists of 132-pound, RE, 39-foot-length rails, which are joined by 6-hole, 36-inch angle bars. The outside rails of the curve are a mixture of curvemaster and flame-hardened rails which were laid second position in 1973. There are about 12 rail anchors in each 39-foot length. The rails rest on 7 7/8- by 14-inch, 7-hole tie plates, which are supported by an average of 22 wood crossties in each 39-foot rail; the crossties rest on slag ballast. There are three to five spikes per tie per rail; this is in excess of the required number of spikes specified in the Federal Railroad Administration (FRA) Track Safety Standards. The curve on which the train derailed has a superelevation of about 4.1 inches (See Figure 4.) The variations in elevation and curvature generally are oscillatory in nature, going from more than median to less than median. These reversals occur in very short distances, and could cause the trucks of the locomotive to follow this pattern. Impulse lateral forces, as a result of this action, could be expected in addition to the lateral forces exerted in a normal curve negotiation. The gauge of the track through the curve varies from 4 feet 8 1/4 inches to 4 feet 8 7/8 inches. The standard gauge measurement is 4 feet 8 1/2 inches.

The Federal Track Safety Standards in effect are contained in 49 CFR 213. The FRA track inspector had noted no discrepancies in the track before the derailment, and he did not find any irregularities in the undisturbed track during his postaccident inspection.

The track is classified as Class 4, 2/ according to the Track Safety Standards. These standards set 57 mph as the maximum allowable operating speed for a 3^{o} 15' curve with 4 1/2 inches of superelevation (49 CFR 213.57 (b)). The curve at milepost BA 258.1 has a curvature of 3^{o} 8' and a speed limit of 60 mph. However, the Track Safety Standards allow a deviation of 1 1/4 inches on the superelevation of a curve (49 CFR 213.63) and a deviation in curvature of 1^{o} 30' (49 CFR 213.55). 3/ This means that the elevation can be as little as 3 1/4 inches or as great as 5 3/4 inches and can have a maximum allowable operating speed of 60 mph.

2/ A Class 4 classification indicates that the track meets the Track Safety Standard requirements set forth in 49 CFR 213 for a maximum speed limit of 80 mph for passenger trains.

3/ 1.5 inches at midordinate of a 62-foot chord.

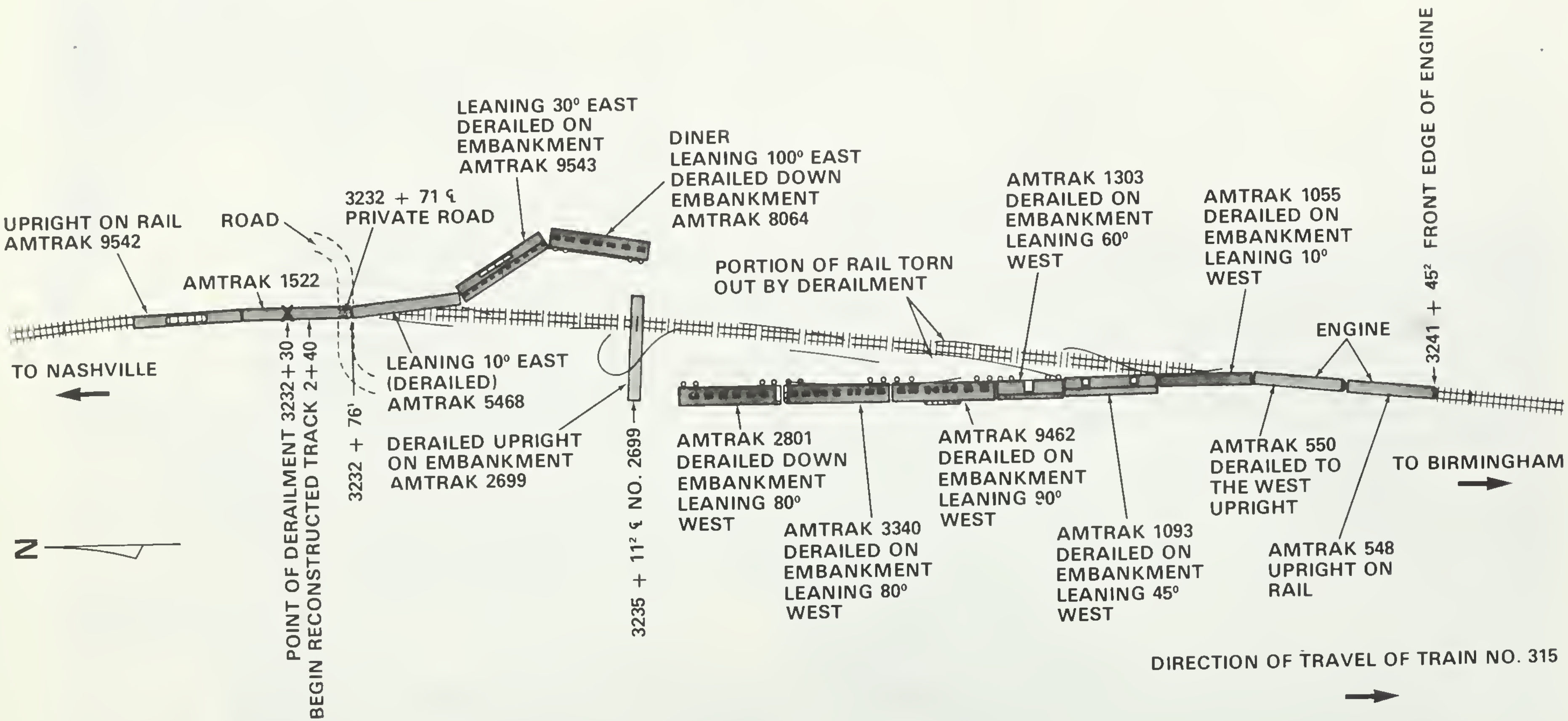


Figure 3. L & N Railroad Company M. P. B. A. 258.1 Frankewing, Tenn., derailment AMTRAK train No. 315, October 1, 1975, curvature 3° 8' R.

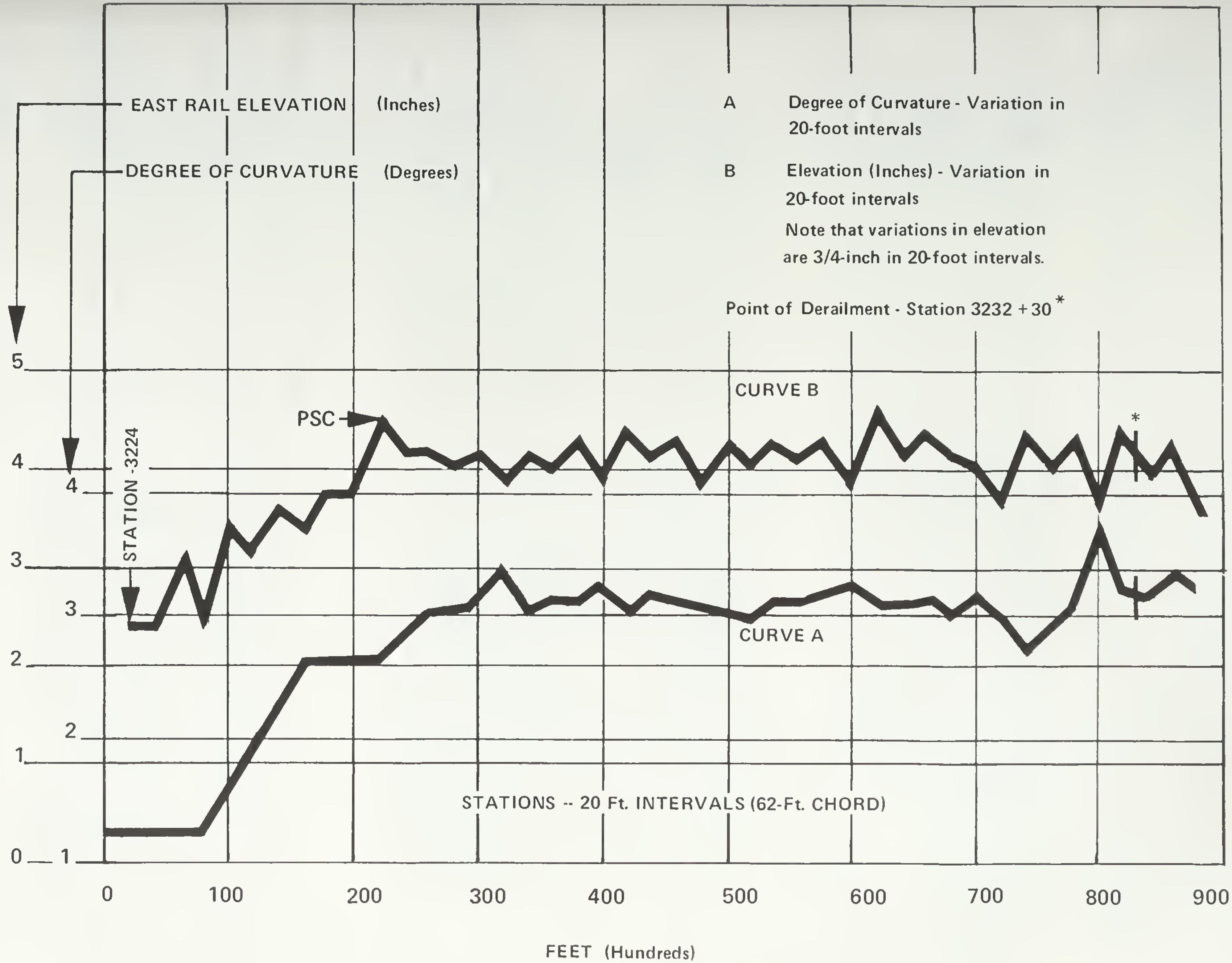


Figure 4. Approach to point of derailment from the north.

An assistant roadmaster inspects the track in the vicinity of milepost BA 258.1 twice weekly. The assistant division engineer had patrolled the track on September 29, 1975, and noted no discrepancies.

On September 17, 1975, the L&N tested the rails through the area of the accident with an ultrasonic rail-test car and determined that the track was in good condition.

On the day that the derailment occurred, an L&N work train, Work Extra 4082, had moved through the area of the derailment in both directions; it last passed milepost BA 258.1 at 11:19 a.m. as it moved south. Another train, Extra 4053 South, passed milepost BA 258.1 at 11:52 a.m. Neither the engineer of Work Extra 4082 nor the engineer of Extra 4053 South noted any irregularities in the appearance or the riding qualities of the track at that point. Unit 4053 was a type GP-38, four-wheel, truck locomotive.

Method of Operation

The accident occurred on the Birmingham Division of the L&N. Trains are operated over this portion of the Birmingham Division by train orders, timetable, general orders, bulletins, and automatic block signal indications. The signals are approach-lighted and are part of a traffic control system which is controlled from Birmingham, Alabama. The operating rules which govern L&N employees are contained in "Rules of the Operating Department," which was effective on July 1, 1966. Operating Rules 550 through 575 govern the movement of trains through the area where the accident occurred. There is no evidence that the crew of No. 315 violated any rules; speed recorder tapes on each locomotive unit indicated that the train's speed had been 60 mph immediately before the engineer made the emergency brake application. Also, there is no evidence that the crews of the track department were remiss in any of their responsibilities.

The Train

The train's consist was locomotive units 548 and 550, three baggage cars, two coaches, two sleeping cars, one dining car, and four coaches. The baggage cars were constructed of steel; the passenger cars were conventional, lightweight cars which were constructed of stainless steel and were equipped with tightlock couplers. The locomotive units were EMD (ElectroMotive Division, General Motors), SDP-40-F, passenger locomotives, which were built to Amtrak's specifications and were owned by Amtrak. (See Appendix A.) These locomotives are heavier than other type SD-40 locomotives. They were maintained by the Seaboard Coastline Railroad at Waycross, Georgia, and Hialeah, Florida.

Each locomotive unit was equipped with alertor, a deadman control, speedometers and speed-recording tapes, and an operable radio. The conductor was also provided with an operable portable radio, with which

he could communicate with the engineer. The units did not have automatic train stop, speed-control, or cab signal equipment. They were subject to inspections and tests in accordance with the Federal Locomotive Inspection Act; they had not violated any of the requirements of the Act.

The locomotive units were equipped with an HT-C 3-axle truck like those used on other EMD products. These six-wheel truck locomotives have been involved in several accidents in which the rail apparently spread under them and turned over. This occurence seems to be more prevalent in a curve. Amtrak has tested the SDP-40-F locomotive on the tracks of the Penn Central Transportation Company (PC), and has determined that it develops high lateral accelerations which may produce excessive lateral forces.

The measured track lateral forces obtained during the tests for an E-8 locomotive (four-wheel truck) and an SDP-40-F locomotive are shown in Table 1.

TABLE 1

Speed	Track Lateral Force	
	SDP-40-F	E-8
65 mph	13,500 lbs	15,000 lbs
85 mph	24,000 lbs	21,500 lbs

When the engineer made the running brake test as the train was leaving Chicago, Illinois, the brakes made an undesired emergency application. The brakes were inspected but no defects which could have caused them to apply were found. The brakes made four other undesired emergency applications between Louisville, Kentucky, and the accident site. In three of these five instances, the brakes were not being used. Although the brakes were inspected repeatedly, no defects were found.

Damage to Property and Equipment

The L&N estimated the damage to the track and the cost of restoring the track and roadbed to be $27,300. The damage to the Amtrak equipment was estimated at $1.04 million.

Some windows in the dining car were shattered, but none were broken out as a result of the derailment. Some of the equipment had floors and undercarriages damaged by rails picked up during the derailment. Other damage was exterior denting and general crash marring.

Postaccident Inspection and Tests

After the derailment, investigators found marks on the rear wheels of the rear truck of locomotive unit 548 which indicated that

the wheels had been derailed and that they had struck track angle bars, tie plates, and spikes. All wheels on unit 550 had been scarred by the derailment. The trucks of unit 550 were removed from the body assembly and its critical clearances and distances, as designated by the manufacturer, were measured. All measurements were within the design specifications or tolerances. No defects that could have caused the accident were found. (See Appendix B.)

Investigators determined that the locomotive stopped 915 feet beyond the first marks of the derailment. The first marks of the derailment were evident on the track structure at the south end of the curve, 60.1 feet north of the PCS (point of curve spiral). The spiral extends southward 288.7 feet to tangent track. A number of broken rails and battered joints, which resulted from the derailment, were found. One broken rail, which investigators suspected had caused the derailment, was found 83 feet south of the first marks of the derailment.

There were no batter marks on the receiving end of this rail. The break in this rail was analyzed by the Technical Center in the Research and Test Department of the Association of American Railroads. The tests indicated that bending stresses, caused by wheel flanges as they rolled in the web, had caused the rail to break.

The derailment demolished about 760 feet of track. The track's condition before the derailment occurred could not be determined except from the inspection records. However, the records, the inspection, and the measurements made of the track adjacent to the destroyed track, the curve geometry, and the tolerance of the track indicate that it was in compliance with the requirements specified by the FRA Track Safety Standards.

When the rail was examined after the accident, some of the line-holding spikes were raised and a few of them were loose enough to be pulled out by hand, but there was no evidence that the tie plates or the rail had moved laterally. The overall conditions of the wood ties was good, and the track was well-drained and well-maintained.

The brake system on each car was checked after the accident and Amtrak car No. 2699 was found to have a faulty brake valve. It failed to pass test No. 5 (test procedures, page 76, Manual No. 5039-21, Westinghouse Airbrake Company). During the bench test, reduction in air pressure initiated an emergency brake application on No. 2699.

ANALYSIS

The Derailment

As No. 315 moved southward through the curve at milepost BA 258.1, the second locomotive unit caused the outside rail to spread and to

overturn. The wheels of the locomotive unit and the wheels of the following equipment must have traveled in the web of the rail, because the heavy marks in the webs of the east and west rails and the gouging and battering on the joint bars indicates that they were struck by the wheels of the train. The westward inclination of the second locomotive unit which was noticed by the fireman indicates that the east wheels were in the web of the rail and that the west wheels were off the rail.

When the west rail broke about 500 feet beyond the point of derailment, the third car and the cars behind it began to derail toward the west. As the third car and the cars behind it went over the embankment, they pulled the head cars off the track structure and roadbed. Probably the broken rail found 83 feet south of the derailment broke under the seventh car. This rail already was stressed badly by the locomotives and by the cars which had run over it with their wheels in the web. When it broke and separated, it allowed the eighth car to move toward the east and down the embankment. The diner pulled the cars behind it down the east side of the fill. At the beginning of this action, the entire train was still coupled. As a result of the gyrations of the cars, car No. 7 came uncoupled at both ends and came to rest perpendicular to the track. Except for car No. 7 the train did not uncouple. Undoubtedly, the fact that the train remained coupled prevented any violent gyrations and kept the cars from rolling over completely.

Overturning of the Track

The L&N restricts the speed of passenger trains to 60 mph through the curve at milepost BA 258.1. This is the maximum allowable operating speed for a 3° 8' curve according to the formula prescribed in 49 CFR 213.57(b).

The maximum allowable operating speed as determined by this formula is based on a combination of such factors as speed, superelevation, and degree of curvature. Theoretically these factors set physical parameters that will not allow the generation of a lateral force which could cause the rail to overturn.

The curvature and the elevation of the track vary considerably along the curve in which the derailment occurred. However, these variations are within the tolerances allowed by the Federal Track Standards. The Manual for Railway Engineering (Fixed Properties), the American Railway Engineering Association, and the Engineering Division of the Association of American Railroads (Section 5-3-10) indicate that the elevation for equilibrium speed 4/ for a 3° curve at 60 mph is 7.56 inches.

4/ Equilibrium speed is the speed at which the components of the centrifugal force and the weight in the plane of the track are balanced.

According to their criteria, a 3^{o} curve should have an equilibrium elevation of 7.9 inches. Since the elevation for the curve at milepost BA 258.1 is only half of that required for equilibrium at 60 mph, a train will exert a lateral force on the curve's outside rail because it rides hard against that rail. The net effect of a decrease in elevation would be an increase in lateral force against the outside rail, because the elevation required for equilibrium would have decreased further.

At 60 mph, there is an unknown value of sustained lateral force against the outside rail of the curve, and variations in the track geometry generate additional lateral forces. These forces are induced as impulses because the wheels of the locomotive strike the uneven points in the alignment of the curve. This could cause an oscillatory harmonic effect, in which case these impulses would be cumulative, and add to those lateral forces already present. Engineering performance tests show that six-wheel trucks produce a higher lateral thrust than do four-wheel trucks. Also, six-wheel trucks are less tolerant of certain track defects than are four-wheel trucks.

Consequently, it appears that at least three factors were present which caused the rail to overturn:

a) The speed of No. 315 was equal to the maximum allowable speed for the curve but above the speed necessary to maintain equilibrium.

b) The cumulative impulse effects, which were produced by the variation in track geometry, tended to increase the lateral force.

c) The six-wheel trucks generated a higher lateral force than four-wheel trucks.

The rail's resistance to overturning is not known because the exact condition of the track before the derailment is not known.

There have been at least three other accidents 5/ that have occurred under similar circumstances -- i.e., a 3^{o} -plus curve, a speed of 55 to 60 mph, and a locomotive with six-wheel trucks. These accidents suggest that the rail's resistance to overturning and the effect of variations in curve geometry on six-wheel trucks should be studied. Locomotive manufacturers, Amtrak, the railroads, and the FRA should cooperate in this effort. The FRA Track Safety Standards also should be reviewed to determine if they are adequate for the stresses imposed by six-wheel trucks.

5/ Amtrak Train No. 10 on Burlington Northern tracks at Flynn, Montana, January 5, 1976.

Amtrak Train No. 15 on Atchison, Topeka and Santa Fe tracks at Ardmore, Oklahoma, January 14, 1974.

Amtrak Train No. 81 on Seaboard Coastline tracks at Wake Forest, North Carolina, August 12, 1974.

Track-Train Dynamics

Both the railroad industry and The Federal Railroad Administration have studied track-train dynamics. The manufacturers of the six-wheel truck present a substantial amount of test data which indicates, in theory, that the performance of the six-wheel trucks is superior to that of four-wheel trucks in some instances and that the reactive forces generated by the two are nearly the same for all cases except for that of a lateral force. They admit that a six-wheel truck generates more lateral force than does a four-wheel truck, but they claim that the force is still below that which is required to overturn a rail or to cause a wheel to climb up on the rail. Since the forces required to overturn a rail or to cause a car wheel to climb out of the gauge have been determined to be a relationship between lateral forces (L) and vertical forces (V), the manufacturers have established L/V ratios as criteria for forces required for rail overturn or for wheel climb. In order for a rail to overturn, the L/V ratio has to exceed 0.5 or 0.6 and in order for a wheel to climb the rail, the L/V ratio has to exceed 0.9. Tests show that the L/V ratio for an SDP-40-F locomotive is well below these values. Therefore, the concensus among the manufacturers is that the amount of lateral force generated is not the only factor which causes a rail to overturn. The manufacturers believe that the duration of lateral load is also a factor. An L/V ratio of 0.5 or 0.6 generally will not cause a rail to overturn unless the high ratio is maintained for a period of time. Curvature of the rails may also be a factor; the problem of rails being overturned by six-wheel trucks seems to be more evident in curves with a curvature greater than 2^{o}.

Since there are unknown factors involved, possibly the tolerance n track geometry as outlined by the Track Safety Standards allows too much variance to accommodate the six-wheel truck locomotives.

escue and Escape Procedures

Passenger equipment of the type used on No. 315 does not permit apid access for rescue operations or rapid escape for passengers.

When a passenger car is on its side, usually the only way out of he car is to climb up. Without planned footrests or handholds to assist assengers to climb up from within the vestibule, escape from the car s hindered and becomes hazardous. Handrails, which aid passengers who re detraining from an upright car, and car construction ledges are the nly available footing on the end vestibule opening.

Loose furniture and tableware also hindered escape efforts. Much this equipment had to be moved before an escape passageway could be stablished. In order to escape from the diner, passengers had to crawl er open doorways which had no stablizing guidebars or handrails. Rescue

personnel worked from the outside of the car to help passengers overcome some of these impediments, but they were hampered in their efforts because their access to the inside of the car was limited.

Possible Emergency Brake Application

It could not be determined whether an undesired emergency brake application occurred just before the derailment. However, even if an emergency brake application had been initiated by the defective brake valve on the seventh car, it would not have increased the tendency of the locomotive to overturn the rail. Since the train was being operated under power with a slight brake application, the train should have been stretched. If emergency braking had been initiated at the seventh car, the tension would have been maintained in the train. This would have tended to decrease the lateral force which locomotive wheels were exerting on the outside rail.

CONCLUSIONS

1. The crew operated train No. 315 in accordance with applicable rules.

2. The track condition and the maintenance schedule conformed with the FRA Track Safety Standards for Class 4 track.

3. Car No. 2659 was being operated with a faulty brake valve which apparently caused several unwanted emergency brake applications.

4. An undesired emergency brake application at milepost BA 258.1 would not have increased the tendency of the locomotive to overturn the rail.

5. The variations in elevation and track curvature could have set up the condition necessary for the locomotive to develop excessive lateral forces, which exceeded the rail's resistance and caused it to turn over.

6. The broken rails found after the derailment at the scene of the accident were broken during the derailment.

7. The rails were broken because of bending stresses caused by the wheel flanges as they rolled in the web.

8. The outside rail was turned over by the lead truck of the second locomotive unit by a combination of high lateral forces generated by the six-wheel truck locomotive, and the inability of the track structure to accommodate those forces even though the track met the applicable FRA standards for Class 4 track.

9. There is a need to continue to study the phenomena associated with rail climb and rail overturn in connection with the six-wheel truck to determine the cause and the method to correct it.

10. Sliding end doors on passenger cars cannot be opened without mechanical aids when the required movement is upward.

11. When a car comes to rest at a severe angle, escape routes from the car's interior are obstructed by open compartment doors and hanging curtains, and escape is restricted by the lack of escape hatches in the ceiling of the car.

12. Loose furniture is a hazard during an accident because it may hit persons or block escape routes.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail in a 3° 8' curve by high lateral forces induced by the six-wheel truck of the SDP-40-F locomotive; these forces exceeded the capability of the track which met current FRA standards. The speed of the locomotive, although not greater than the speed allowable for Class 4 track, was too great to be sustained by the track.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations to the Federal Railroad Administration:

"Review the Federal Track Safety Standards to determine if their current requirements are adequate for the safe accommodation of the six-wheel truck locomotives. (R-76-20)

"Require that rail passenger equipment be fitted with roof hatches so that passengers can escape through the ceiling of a car which is lying on its side. (R-76-21)

"Require that Amtrak or the railroad operating an Amtrak train disseminate information to emergency units along the route on emergency entry techniques and on where emergency equipment within the car is located. (R-76-22)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD.

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

May 10, 1976

APPENDIX A

Excerpts from GM Technical Manual for SDP-40-F Locomotive

MODEL	SDP40F 3000 HP Six Motor Diesel-Electric Locomotive.
TYPE	AAR designation (C-C), Common Designation (0660).

*****

NOMINAL DIMENSIONS

Distance, pulling face of coupler to centerline of truck	Front 12'8"
	Rear 13'8"
Distance between bolster centers	46'0"
Truck -- rigid wheel base	13'7"
Distance, pulling face front coupler to rear coupler	72'4"

*****

DRIVE

Driving motors	Six
Driving wheels	6 Pair
Diameter wheels	40"
Gear Ratio	57:20

WEIGHTS AND SUPPLIES

Total loaded weight on rails (including calculated weight of dual steam generators and 6000 gallon total fuel and water capacity) 396,000# $\pm$ 4,000

*****

CURVE NEGOTIATION

Truck swing limits single unit curve negotiation to a 30^{o} or 193 ft. radius curve.

Two units coupled in multiple limited by coupler swing to a 21^{o} or 274 ft. radius curve (equipped with "E" coupler).

Locomotive coupled to an 87 ft. passenger car limited by car coupler swing to a 19^{o}30' or 295 ft. radius curve (equipped with "E" coupler).

Two units coupled in multiple limited by coupler swing to a 19^{o}30' or 295 ft. radius curve (equipped with "F" coupler).

Locomotive coupled to an 87 ft. passenger car limited by car coupler swing to a 17^{o}30' or 330 ft. radius curve (equipped with "F" coupler).

APPENDIX A

TRUCK ASSEMBLIES	Two flexible, three motor, six wheel high traction, HTC truck assemblies are provided per locomotive. The high traction performance of the HTC truck is accomplished by three design characteristics: a large diameter center bearing, a stiff bolster suspension coupled with a relatively soft journal suspension, and traction motors oriented in one direction in each truck. The new high traction truck is not interchangeable with previous three-axle trucks; however, there is a high degree of interchangeability maintained between truck components. Moreover, the simplicity of the HTC truck design enhances accessibility and maintainability.
PRIMARY SUSPENSION	A relatively soft primary suspension is provided by a combination of journal springs and hydraulic shock absorbers. The double coil journal spring assemblies minimize wheel load variations caused by rail profile irregularities. Hydraulic shock absorbers between the truck frame and middle axle journal boxes provide the vertical damping necessary for good riding quality.
SECONDARY SUSPENSION	Four stiff rubber pads, located between the truck frame and H shaped bolster, constitute the secondary suspension. These sandwich type pads are the primary factor in limiting weight transfer and are the principal source of lateral damping for the truck. In addition, the rubber pads both isolate the road noise which was previously transmitted between the bolster and the truck through steel springs, and provide additional vertical snubbing for the suspension.
AXLES	Axles with 6-7/8" journals to suit Hyatt roller bearings. Axle material conforms to physical properties of current AAR specifications. Axles are splined at one end only.
WHEELS	Class BR wrought steel heat treated, rim quenched, 40" diameter with 2-1/2" rim. Wheel treads with cylindrical contour are finished smooth and concentric. AAR diameter index groove is provided to measure true wheel diameter for wheel size matching. All wheels are hub stamped in accordance with AAR alternate marking.

APPENDIX A

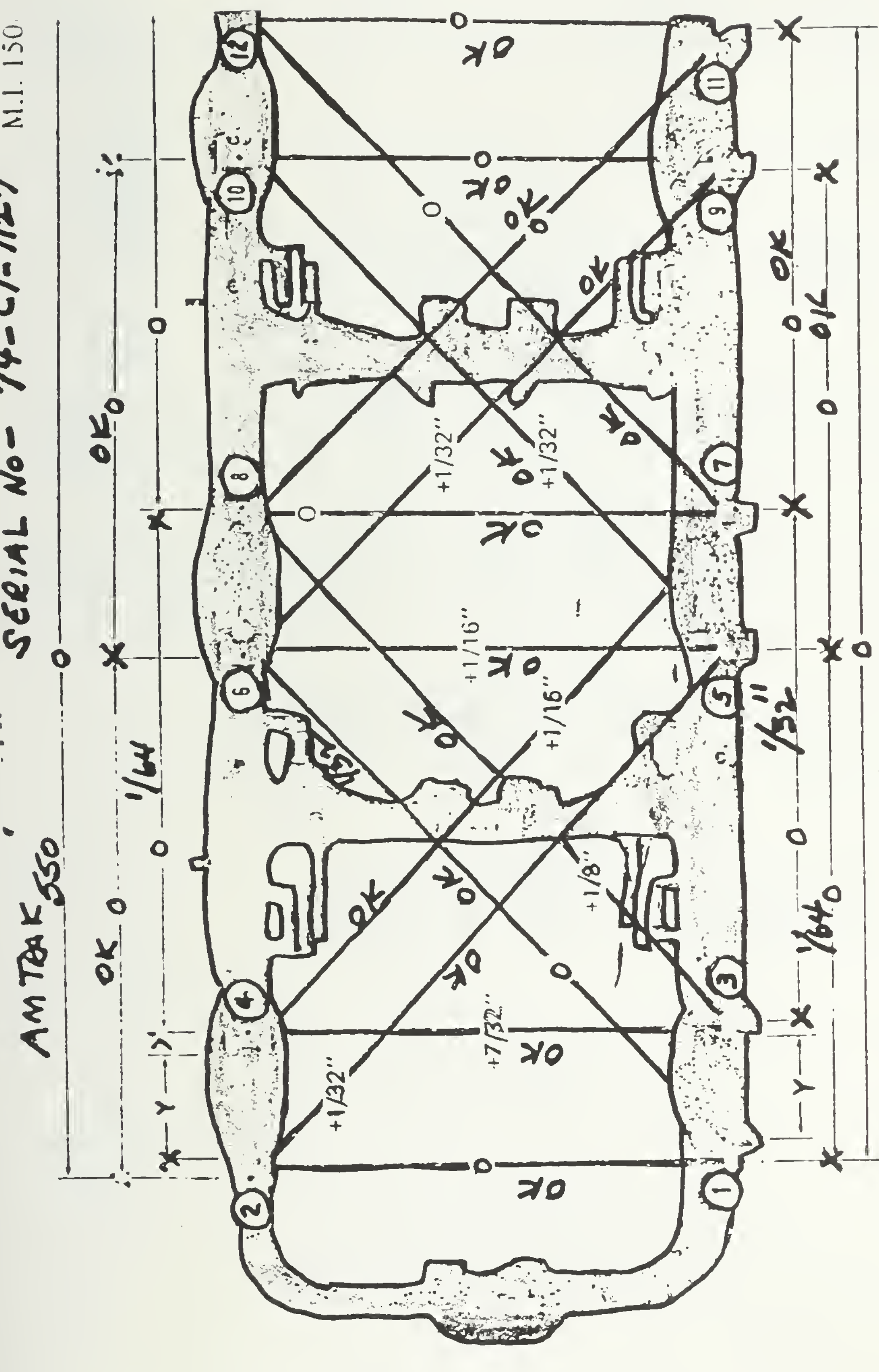
JOURNAL BOXES	Locomotive equipped with Hyatt JEM roller bearings of EMD design. Improved rear cover seal and oil fill cup for improved oil retention and inspection provided. Crowned rollers extend bearing life. Lateral thrust is taken through a cushioning arrangement directly by the box with improved oil flow characteristics over thrust block. Journal box pedestal guides provided with spring steel wear plates.
PEDESTALS	Equipped with composition nylon liners bolted to frame.
PEDESTAL TIE BARS	Fitted and applied at the lower end of the pedestal legs, held in position by bolts.
TRUCK CENTER BEARING RECEPTACLE	Truck center bearing receptacle provided with wear plates and rubber dust guard.
SIDE BEARINGS	Friction type side bearings.
INTERLOCKS	Body and truck interlocks serve as safety devices in case of derailment. Antisluing stops are provided between truck bolster and underframe bottom plate.
TRUCK BRAKES	Single shoe type brake rigging provided on each wheel, operated by four truck frame mounted brake cylinders. Composition shoes are standard.
SLACK ADJUSTERS	EMD design pin type slack adjusters.
BRAKE PINS	All pins and bushings hardened and ground.
HAND BRAKE	Hand brake provided for the locomotive operates on two axles of one truck. Both trucks provided with a lever for hand brake connection, making trucks interchangeable. Application of a 125 pound force to the rim of the 20" hand brake wheel will provide sufficient braking power to hold the fully loaded locomotive on a 3% grade. Hand brake modified with shortened shaft to allow maximum aisle clearance.
GEAR RATIO	57:20 gear ratio provides full horsepower to 94 MPH and a minimum continuous speed of 16.1 MPH.

APPENDIX A

INSPECTION COVERS	Traction motors provided with quick access hinged type bottom inspection covers.
HUCK FASTENERS	Huck bolts are provided on traction motor gear cases.

APPENDIX B

RESULTS OF TESTS ON SDP-40-F LOCOMOTIVE



(Some lines omitted for simplicity)

Truck measurements of locomotive 550.

APPENDIX B

Locomotive 550 -- measurements (inches)

	Front	Rear
Coupler swing -	L.S. - 3 3/4" R.S. - 1",	L.S. - 2" R.S. 3 1/2"
Coupler height-	34"	33"

Bolster Wear Plates

Front	R.S. 1/8" -- L.S. 1/16"
Rear	R.S. 1/8" -- L.S. 1/8"

Box Liner Lateral

R1 - 3/16", R2 - ¼", R3 - 3/16", R4 - 3/16", R5 - ¼", R6 - 3/16",
L1 - 5/16", L2 - 5/16", L3 - 3/16", L4 - ¼", L5 - ¼", L6 - 3/16"

Pedestal Liner to J-box

R1 - 5/32", R2 - ¼", R3 - 5/32", R4 - ¼", R5 - 5/16", R6 - 3/16"
L1 - 3/32", L2 - 3/16", L3 - 3/16", L4 - 3/16", L5 - 1/8", L6 - 1/8"

Side Bearing Clearance

R1 - ¼", R2 - 1/8", R3 - 23/32", R4 - ¼",
L1 - ¼", L2 - ¼", L3 - ¼", L4 - 5/16"

Wheel Tram

1- 53 5/16"	2- 53 5/16"	3- 53 5/16"
4- 53 5/16"	5- 53 5/16"	6- 53 5/16"

APPENDIX B

UNIT 550
DATE 10-7-75

	FLANGE THICKNESS			HEIGHT OF FLANGE				RIM THICKNESS			
R1	5	L1	5	R1	1 1/8	L1	1 1/8	R1	1 5/8	L1	1 11/16
R2	2	L2	2	R2	1 1/8	L2	1 1/8	R2	1 7/8	L2	2
R3	0	L3	1	R3	1 3/16	L3	1 1/8	R3	2 1/4	L3	2 1/4
R4	2	L4	2	R4	1 1/16	L4	1 1/16	R4	2	L4	2
R5	-2	L5	2	R5	1 1/8	L5	1 1/8	R5	1 7/8	L5	1 7/8
R6	0	L6	1	R6	1 1/8	L6	1 1/8	R6	2 3/16	L6	2 1/4

FORM NO. 1441.E.2-12.65
L & N R R CO
OFFICE GENERAL SUPT. MOTIVE POWER

Inspector /s/ J. D. Bunch

Foreman

Wheel measurements (inches)

BRAKE REPORT

DATE MADE 10-3-75

LOCOMOTIVE UNIT # AMT 550

PISTON TRAVEL (inches)				WHEEL REPORT SPOTS OR FLATS			
R 1	3-3/16	L 1	3	R 1	None	L 1	
R 2	2-13/16	L 2	2-7/8	R 2	"	L 2	
R 3	2-3/4	L 3	2-1/4	R 3	"	L 3	
R 4	1-1/2	L 4	1-1/2	R 4	"	L 4	
R 5		L 5		R 5		L 5	
R 6		L 6		R 6		L 6	

ENGINE BRAKE APPLY LBS 72 SECONDS 4 RELEASE SECONDS 4 HOLDS

AUTOMATIC BRAKE APPLY LBS 78 SECONDS 9 RELEASE SECONDS 9 HOLDS

EMERGENCY BRAKE APPLY LBS 93 SECONDS 13 RELEASE SECONDS 19 HOLDS

BRAKE PIPE LEAKAGE LBS 0 PER MINUTE

MAIN RESERVOIR LEAKAGE LBS 0 PER MINUTE

ORIFICE AIR COMPRESSOR GOOD

MAIN RES. CHECK VALVE GOOD

CONDITION BRAKE SHOES GOOD FITTED TO WHEELS GOOD

CONDITION BRAKE RIGGING GOOD

MANUAL OPERATING
Sand only of LF and RB
ALL SANDERS OPEN AND LINED TO RAIL

Air on all sanders

EMERGENCY SANDING OPERATING

TEST DATES

MONTHLY 9-23-75

3 Mos.-- 8-2-75

6 Mos.-- "

12 Mos.-- "

24 Mos.-- "

48 Mos.-- 4-17-74

SAFETY CONTROL DEAD MAN PEDAL DUMPS SECONDS
BRAKE CYL PRESSURE- LBS SECONDS
Cut Out

REMARKS--

Inspector (Sign) /s/ Kenneth O. Dotson

Officer in Charge (Sign) Same

APPENDIX B

Loco - AMTRAK 550

Vertical and Horizontal snubbers on No. 1 truck

tested and are fit for service

/s/ J.S. Bush

10-8-75

AMTRAK Locomotive No. 550

#2 TRUCK

Vertical snubber right side defective.

Left snubber and both horizontal snubbers satisfactory

for service.

/s/ W.E. Stoecker

10-9-75

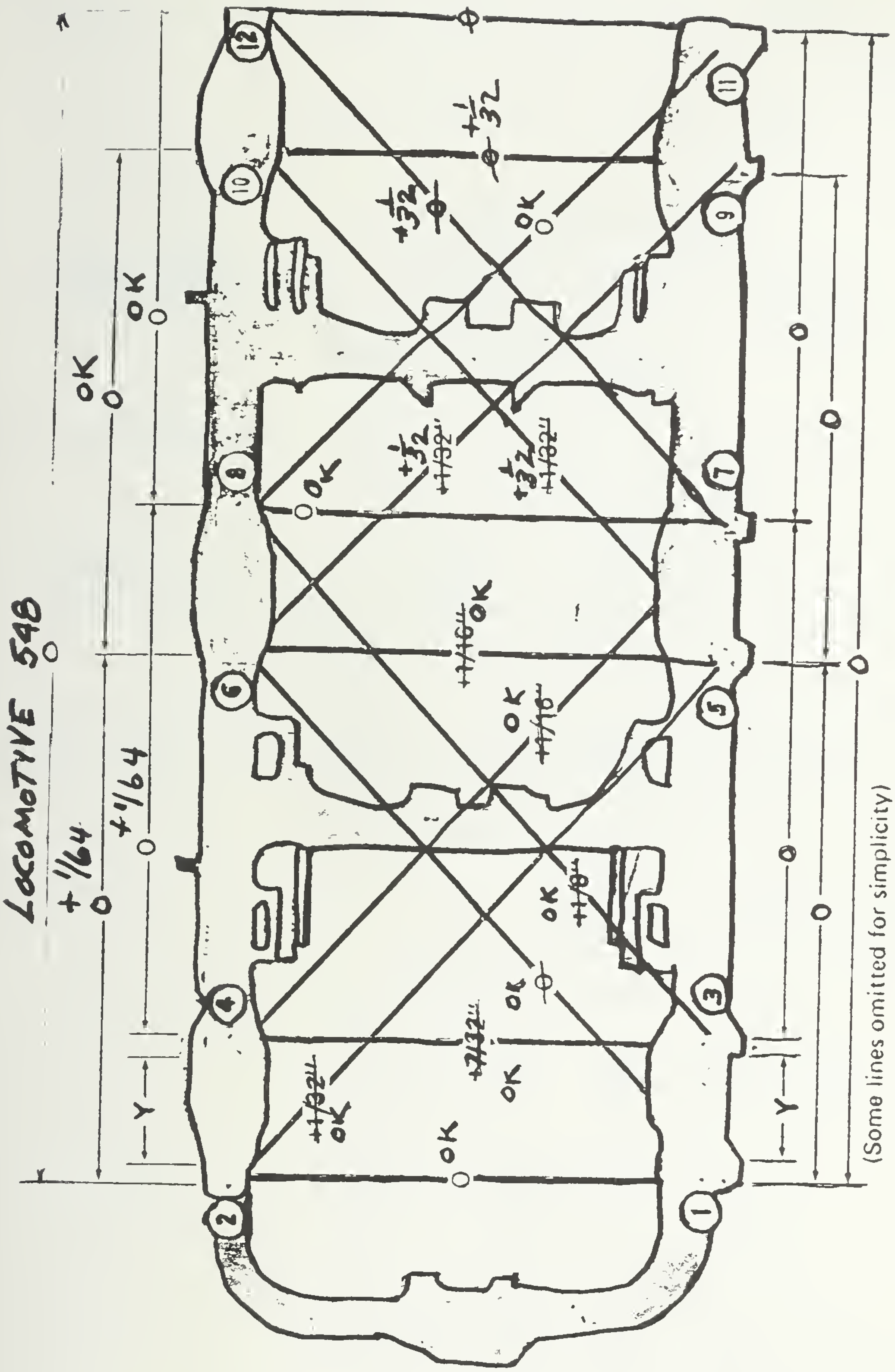
APPENDIX B

Lateral Clearances in Truck (inches)

	#1 Truck			#2 Truck		
WHEEL	#1	#2	#3	#4	#5	#6
Left A	1-7/16	(1-10/16) 1-5/8	1-7/16	1-9/16	1-10/16	1-7/16
Left B	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16
Left C	3/16	(2/16) 1/8	0	2/16	1/16	0
Right A	(1-8/16) 1-1/2	1-7/16	(1-12/16) 1-3/4	1-7/16	1-8/16	1-12/16
Right B	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16	1-7/16
Right C	0	0	3/16	1/16	1/16	2/16
LA + RA + LC + RC	2-18/16	2-19/16	2-22/16	2-19/16	2-20/16	2-21/16
LB + RB	2-14/16	2-14/16	2-14/16	2-14/15	2-14/16	2-14/16
LA + RA + LC + RC - LB - RB	2-(4/16) 1/4	5/16	1/2	5/16	6/16	7/16

Lateral clearances measured in accordance with EMD's No. 1552.

APPENDIX B



Truck measurements of locomotive 548.

APPENDIX B

Locomotive 548 - measurements (inches)

LOCO. 548

	Front		Rear	
Coupler Swing -	L.S. - 3"	R.S. - 3-1/2",	L.S. - 3-1/4" -	R.S. - 4"
Coupler Height -	34"		33-1/2	

Pedestal Liner to Box

R1 - 3/16", R2 - 7/32", R3 - 1/8", R4 - 3/16", R5 - 3/16", R6 - 5/32"
L1 - 3/16", L2 - 7/32", L3 - 7-/32", L4 - 3/16", L5 - 1/4", L6 - 3/16"

Wheel Tram

1 - 53-5/16", 2 - 53-1/4", 3 - 53-1/4", 4 - 53-1/4", 5 - 53-5/16" 6 - 53-5/16"

Side Lateral in J - Box

R1 - 7/32", R2 - 3/16", R3 - 3/16", R4 - 7/36", R5 - 3/16", R6 - 5/32"
L1 - 3/16", L2 - 5/32", L3 - 1/4", L4 - 5/32", L5 - 5/32", L6 - 5/32"

Distance from Bottom of J - Box to Binder

R1 - 3-1/4", R2 - 3-3/4", R3 - 3-3/4", R4 - 4", R5 - 3-3/4", R6 - 3-7/8"
L1 - 3-1/4", L2 - 4-1/4", L3 - 3-7/8", L4 - 3-7/8", L5 - 4", L6 - 3-7/8"

Bolster Wear Plates

R1 - 1/16", R2 - 0" R3 - 1/8", R4 - 0
L1 - 0, L2 - 1/16", L3 - 0, L4 - 1/16"

Side Bearing Clearance

R1 - 5/16", R2 - 7/32", R3 - 5/16", R4 - 7/16"
L1 - 7/16", L2 - 7/16", L3 - 3/8", L4 - 3/8"

APPENDIX B

UNIT 546
DATE 10-7-75

	FLANGE THICKNESS				HEIGHT OF FLANGE				RIM THICKNESS			
R1	2	L1	3	R1	1 1/8	L1	1 1/8	R1	1 3/8	L1	1 3/8
R2	0	L2	4	R2	1 1/4	L2	1 5/16	R2	2 3/16	L2	2 1/8
R3	0	L3	0	R3	1 5/16	L3	1 5/16	R3	2 3/16	L3	2 1/8
R4	1	L4	1	R4	1 1/16	L4	1 1/16	R4	2 1/2	L4	2 1/2
R5	4	L5	0	R5	1 5/16	L5	1 1/4	R5	2 1/8	L5	2 1/8
R6	0	L6	0	R6	1 5/16	L6	1 5/16	R6	2 1/8	L6	2 1/16

FORM NO. 1441.E.2-12.65
L & N R R CO
OFFICE GENERAL SUPT. MOTIVE POWER

Inspector /s/ Watts

Foreman

Wheel measurements (inches)

BRAKE REPORT

APPENDIX B

DATE MADE 10-3-75

LOCOMOTIVE UNIT # AMT. 548

PISTON TRAVEL				WHEEL REPORT SPOTS OR FLATS			
R 1	1-5/8	L 1	2-1/4	R 1	None	L 1	
R 2	3-1/4	L 2	2-1/2	R 2	"	L 2	
R 3	2-7/8	L 3	3-1/2	R 3	"	L 3	
R 4	2-3/8	L 4	2-3/8	R 4	"	L 4	
R 5		L 5		R 5		L 5	
R 6		L 6		R 6		L 6	

ENGINE BRAKE APPLY LBS 72 SECONDS 3 RELEASE SECONDS 5 HOLDS

AUTOMATIC BRAKE APPLY LBS 78 SECONDS 7 RELEASE SECONDS 11 HOLDS

EMERGENCY BRAKE APPLY LBS 93 SECONDS 12 RELEASE SECONDS 18 HOLDS

BRAKE PIPE LEAKAGE LBS 0 PER MINUTE

MAIN RESERVOIR LEAKAGE LBS 1 PER MINUTE

ORIFICE AIR COMPRESSOR GOOD

MAIN RES. CHECK VALVE GOOD

CONDITION BRAKE SHOES GOOD FITTED TO WHEELS GOOD

CONDITION BRAKE RIGGING GOOD

MANUAL OPERATING
Sand pipe bad because of derailment
ALL SANDERS OPEN AND LINED TO RAIL

Air on all sanders

EMERGENCY SANDING OPERATING
SAFETY CONTROL DEAD MAN PEDAL DUMPS SECOND
BRAKE CYL PRESSURE- LBS SECONDS
Cut Out

TEST DATES MONTHLY 9-12-75

3 Mos.-- 7-17-75

6 Mos.-- "

12 Mos.--"

24 Mos.--"

48 Mos.--4-17-74

REMARKS--

Inspector (Sign) /s/ Kenneth O. Dotson

Officer in Charge (Sign) Same

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RAILROAD ACCIDENT REPORT

COLLISION OF PENN CENTRAL TRANSPORTATION COMPANY OPERATED PASSENGER TRAINS NUMBERS 132, 944, AND 939

NEAR WILMINGTON, DELAWARE

OCTOBER 17, 1975

REPORT NUMBER: NTSB-RAR-76-7

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-RAR-76-7	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Railroad Accident Report -- Collision of Penn Central Transportation Company-Operated Passenger Trains Number 132, 944, and 939, Near Wilmington, Delaware, October 17, 1975		5. Report Date June 16, 1976
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Surface Transportation Safety Washington, D.C. 20594		10. Work Unit No. 1831
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Railroad Accident Report October 17, 1975
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

On October 17, 1975, about 6:37 p.m., a northbound Penn Central Transportation Company (Penn Central) passenger train, No. 944, struck the rear of Penn Central train No. 132, which had made an unscheduled stop near Wilmington, Delaware, because of an equipment malfunction. Train No. 939, a southbound Penn Central passenger train that was approaching on an adjacent track, struck the derailed equipment from No. 944. The collisions injured 25 persons and caused property damage of $817,866.

The National Transportation Safety Board determines that the probable cause of the rear end collision was the engineer's failure to operate his train according to established procedures. Contributing to the accident was the operational practice of the railroad industry which permits trains to enter occupied blocks. The second collision was caused by the absence of flagging.

17. Key Words Passenger train collision; derailment; signal indication; communications; visibility impairment; flagging procedures; crashworthiness; operating rules.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
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NTSB Form 1765.2 (Rev. 9/74)

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: June 16, 1976

COLLISION OF PENN CENTRAL TRANSPORTATION COMPANY-OPERATED PASSENGER TRAINS NUMBERS 132, 944, AND 939, NEAR WILMINGTON, DELAWARE, OCTOBER 17, 1975

SYNOPSIS

On October 17, 1975, about 6:37 p.m., a northbound Penn Central Transportation Company (Penn Central) passenger train, No. 944, struck the rear of Penn Central passenger train No. 132, which had made an unscheduled stop near Wilmington, Delaware, because of an equipment malfunction. Train No. 939, a southbound Penn Central passenger train that was approaching on an adjacent track, struck the derailed equipment from No. 944. The collisions injured 25 persons and caused property damage of $817,866.

The National Transportation Safety Board determines that the probable cause of the rear end collision was the engineer's failure to operate his train according to established procedures. Contributing to the accident was the operational practice of the railroad industry which permits trains to enter occupied blocks. The second collision was caused by the absence of flagging.

FACTS

The Accident

On October 17, 1975, an Amtrak passenger train, No. 132, operated by the Penn Central Transportation Company (Penn Central), 1/ departed Washington, D.C., with six cars in its consist. This train was a regularly scheduled Metroliner which operated over Penn Central's track between Washington, D.C., and New York, New York. Because of an equipment malfunction in Washington, northbound No. 132 departed Washington 12 minutes behind schedule and departed Wilmington, Delaware, 14 minutes behind schedule. The train experienced no further mechanical difficulty until after it departed Wilmington.

1/ Penn Central became part of the Consolidated Rail Corporation in April 1976.

As the train approached Milepost (MP) 25, about 1 mile east of Wilmington station, at about 60 mph, the train's brake applied and stopped the train. The locomotive engineer advised the operator at the nearest station that the train's brakes were in emergency and that the train was stopping. The operator attempted to notify No. 944, a five-car Penn Central Silverliner commuter train operated for Southeastern Pennsylvania Transportation Authority (SEPTA). No. 944 was following No. 132 on No. 2 track and had departed Wilmington station 8 minutes late -- 2 minutes behind No. 132. For unknown reasons, No. 944 did not receive the notification that No. 132 was stopped.

When No. 944 departed Wilmington, a thunderstorm was in progress. However, the engineer of No. 944 had turned off the windshield wiper on the cab window because its noise annoyed him. When his train approached signal No. 208L, the signal displayed a "stop and proceed" aspect, and he complied with the indication. His cab signals changed from "restricting" to "approach," and he increased his train's speed to 30 mph; as the train approached the home signal at Landlith Interlocking, No. 118L, he was prepared to stop, in accordance with the "approach" rule. At Landlith Interlocking, the home signal displayed a "stop and proceed" aspect and the cab signals displayed "restricting." The engineer operated his train in accordance with all block signal indications and with the restricted speed rule through Landlith Interlocking.

As No. 944 departed Landlith Interlocking, the cab signal momentarily indicated a false "approach" aspect. The engineer commented to the trainman who was riding with him that No. 132 was gone; he applied full power and accelerated the train to an estimated 25 mph. He then observed the cab signal return to "restricting" after he had called the "approach" signal to the trainman. He did not respond immediately to the "restricting" indication but instead he turned on the cab-window windshield wiper.

The flagman of No. 132, who was in his train's rear car, saw No. 944 as it approached the rear of his train; he ran to the cab and attempted to alert the engineer of No. 944 to the presence of No. 132 by flashing the headlight on the rear of his train. The engineer of No. 944 and the trainman riding in the cab saw the headlight after they already had seen the marker lights on the rear of No. 132, realized that the train was stopped, placed the train's brakes in emergency, and elected to escape from the cab. They entered the coach compartment of the car, shouted a warning to the passengers, and braced themselves. About 6:37 p.m., No. 944 struck the rear of No. 132.

The flagman of No. 132 remained in the cab of the rear car, which maintained its structural integrity during the collision. The cab of No. 944 collapsed inwardly and contacted the inner coach wall. As the trains collided, No. 132 was pushed forward, and standing passengers and crewmembers in both trains were knocked down. Cars from both trains derailed.

After the trains collided, the crewmembers of both trains attended to the passengers' needs and attempted to notify officials of the collision; however, the trains' radios were inoperative, and a crewmember was sent to telephone from a railroad shop near the accident site. The crewmembers intended to flag the adjacent tracks, but there was no flagging equipment on the lead unit of No. 132. Some crewmembers were injured, and crewmembers, who saw men with lights walking in the area north of the derailment, assumed that they would flag opposing trains; they did not.

About 12 minutes after the two trains collided, a southbound Penn Central train (No. 939) which was operated for SEPTA approached on the adjacent track (No. 3), passed No. 132, and scraped a portion of the lead car of No. 944 as No. 939 stopped. After this collision, a crewmember of No. 944 provided flag protection for the rear of his train with a fusee.

As a result of the collisions, 25 persons were injured. Most of them were injured when they struck hard objects. The most seriously injured sustained contusions, broken ribs, and broken collar bones. Total damage to the three trains amounted to $817,886.

Accident Site

The trains collided on No. 2 main track of Penn Central's Northeast Corridor Region, Chesapeake Division, 23 feet south of MP 25. The railroad consisted of three tracks -- "B" track, No. 2 main track, and No. 3 main track. (See Figure 1.) No. 2 was used predominantly for northbound traffic and No. 3 was used predominantly for southbound traffic. South of MP 25, No. 2 track was on a 0.37-percent descending grade and on a 0° 20' curve to the right.

The trains collided about 2,082 feet north of the interlocking limits of Landlith Interlocking, which was controlled remotely from Wilmington Station, and about 4,277 feet north of Signal 118L, which was the last signal passed by No. 944.

Rain was falling and light was fading rapidly when the trains collided.

Method of Operation

Through Landlith Interlocking, speed was restricted to 50 mph. At the accident site, the maximum authorized speeds were 105 mph for No. 132 and 60 mph for the other two trains.

The signals between Wilmington and the accident area consisted of Wilmington Interlocking, territory governed by automatic block signals and cab signals, and Landlith Interlocking. (See Figure 2.) Landlith Interlocking was an electropneumatic interlocking governed by home signal 118L, which controlled northbound traffic through the interlocking to the point of the accident. The interlocking functions were controlled by a 504C code system and the signals were position-light type.

Penn Central's automatic block signal system Rules 501 through 514 and cab signal Rules 550 through 562 applied. Interlocking Rules 605 through 670 were in effect through the Wilmington and the Landlith interlockings. Block operators were assigned at Bell, Delaware, and Wilmington. Automatic block signal and cab signal rules applied from the signal bridge, located 2,147 feet before the point of collision.

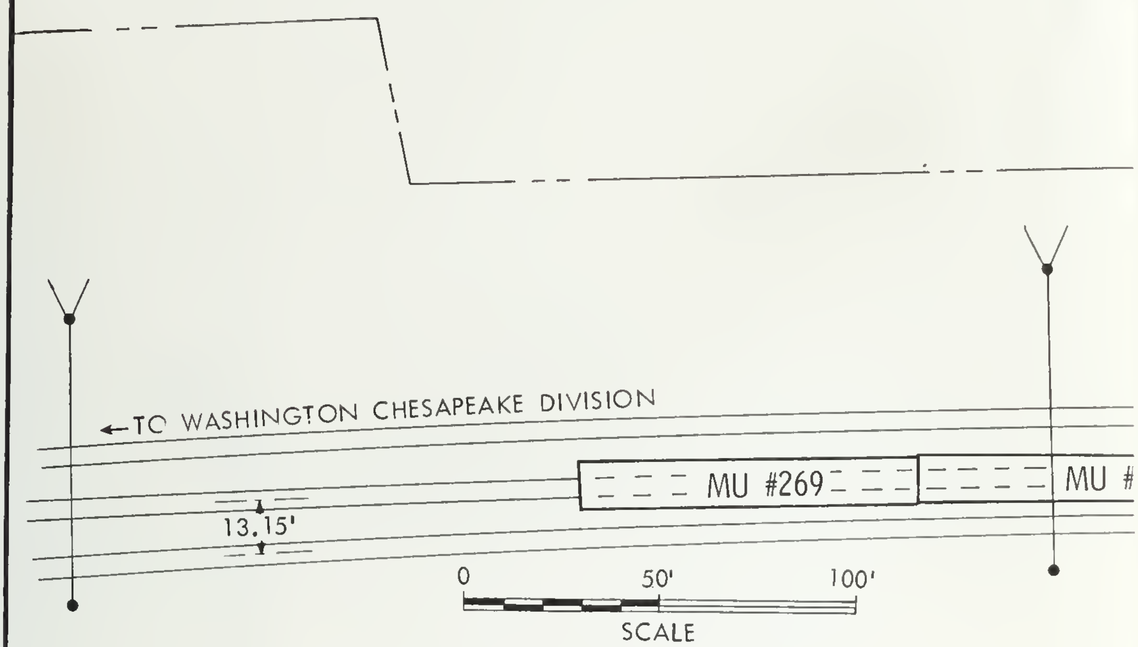
On the day of the accident, signal 118L displayed a "stop and proceed" aspect for No. 944. The "stop and proceed" aspect was defined in Rule 291 of the Penn Central Rules for Conducting Transportation as "stop; then proceed at restricted speed." Restricted speed was defined as "proceed prepared to stop short of train obstruction or switch not properly lined looking out for broken rail, not exceeding 15 mph. NOTE: Speed applies to entire movement."

The engineer of No. 944 saw a "restricting" aspect on his cab signals after he passed 118L. Rule 551(d) stated that "When Cab Signal indication changes to Restricting, a train or engine must reduce speed at once not to exceed Restricted Speed."

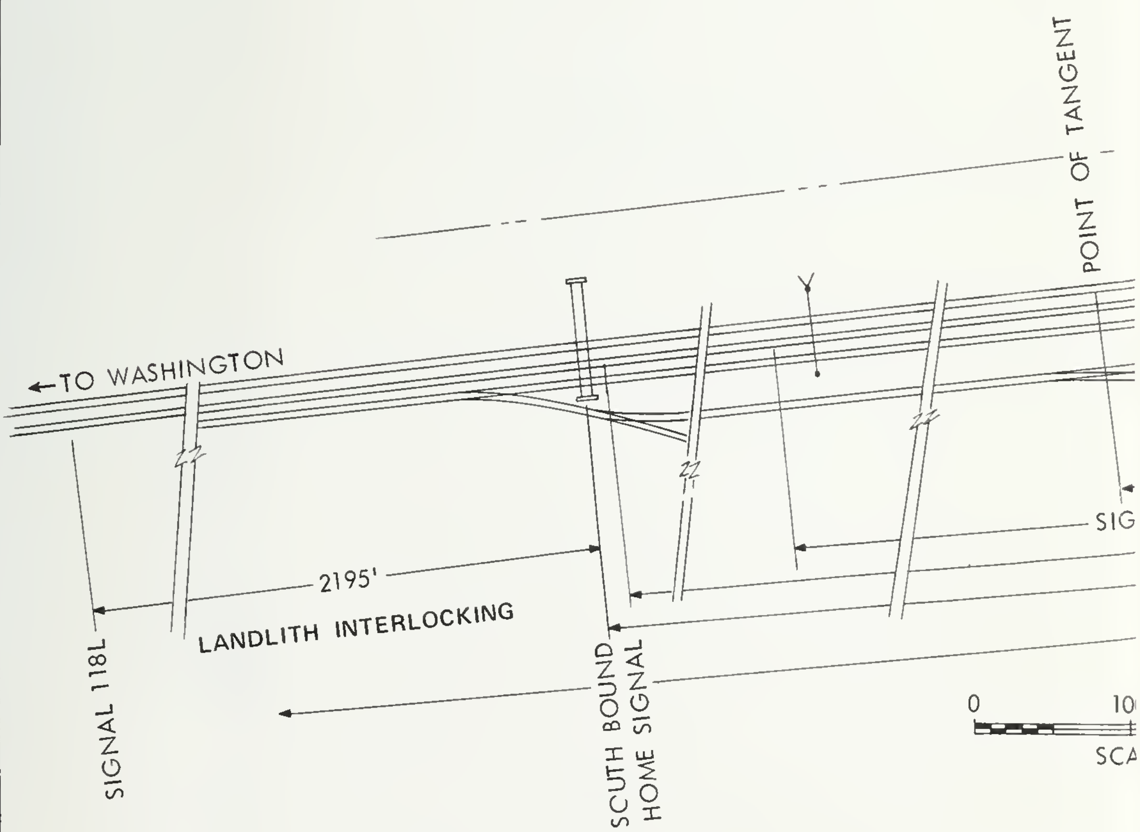
The engineer and brakeman of No. 944 saw the cab signal indicate "approach" just north of Landlith Interlocking. The "approach" indication was defined as: "Proceed prepared to stop at next signal. Trains exceeding Medium speed must at once reduce to that speed." Rule 551(e) stated that "When Cab Signal indication changes from Restricting to a more favorable indication speed must not be increased until train has run its length."

Rule 99 stated that "When a train stops under circumstances in which it may be overtaken by another train, a member of the crew must go back immediately with flagging equipment a sufficient distance to insure full protection, placing two torpedoes, and when necessary, in addition, displaying lighted fusees...When a train is moving under circumstances in which it may be overtaken by another train, a member of the crew must take such action as may be necessary to insure full protection. By night or by day when the view is obscured, lighted fusees must be dropped off at proper intervals...Note -- When trains are operating under automatic block signal system rules or traffic control system rules, the requirements of Rule 99 do not apply for following movements on the same track."

Rule 102 stated that "When a train is disabled or stopped suddenly by an emergency application of the air brakes or other causes, adjacent tracks as well as tracks of other railroads that are liable to be obstructed must, while stopping and when stopped, be protected in both directions until it is ascertained they are safe and clear for the movement of trains."



←TO WASHINGTON CHESAPEAKE DIVISION
MU #269
MU #
13.15'
0
50'
100'
SCALE



←TO WASHINGTON
POINT OF TANGENT
2195'
LANDLITH INTERLOCKING
SIGNAL 118L
SOUTH BOUND HOME SIGNAL
SIG
0
SCA

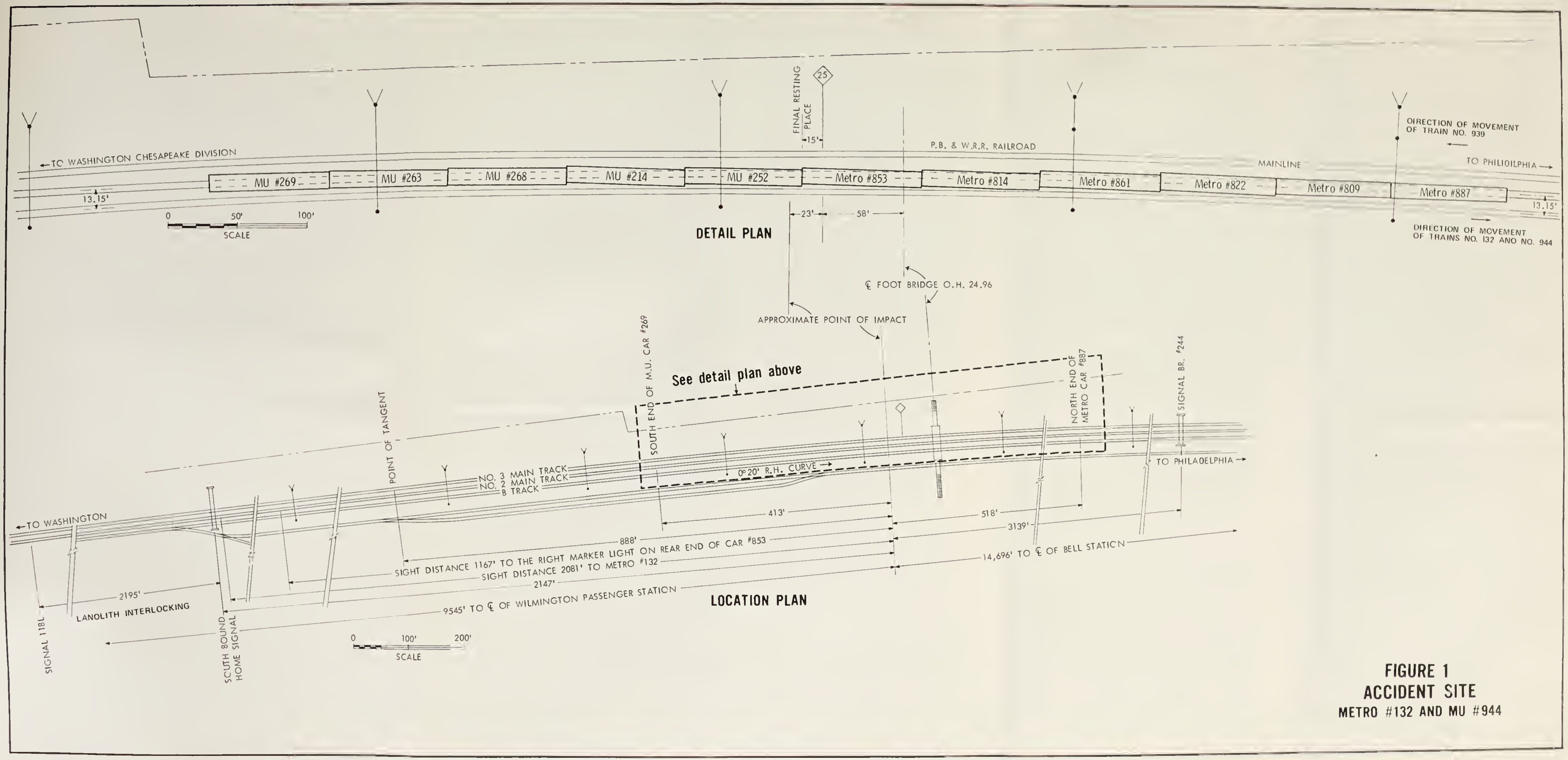
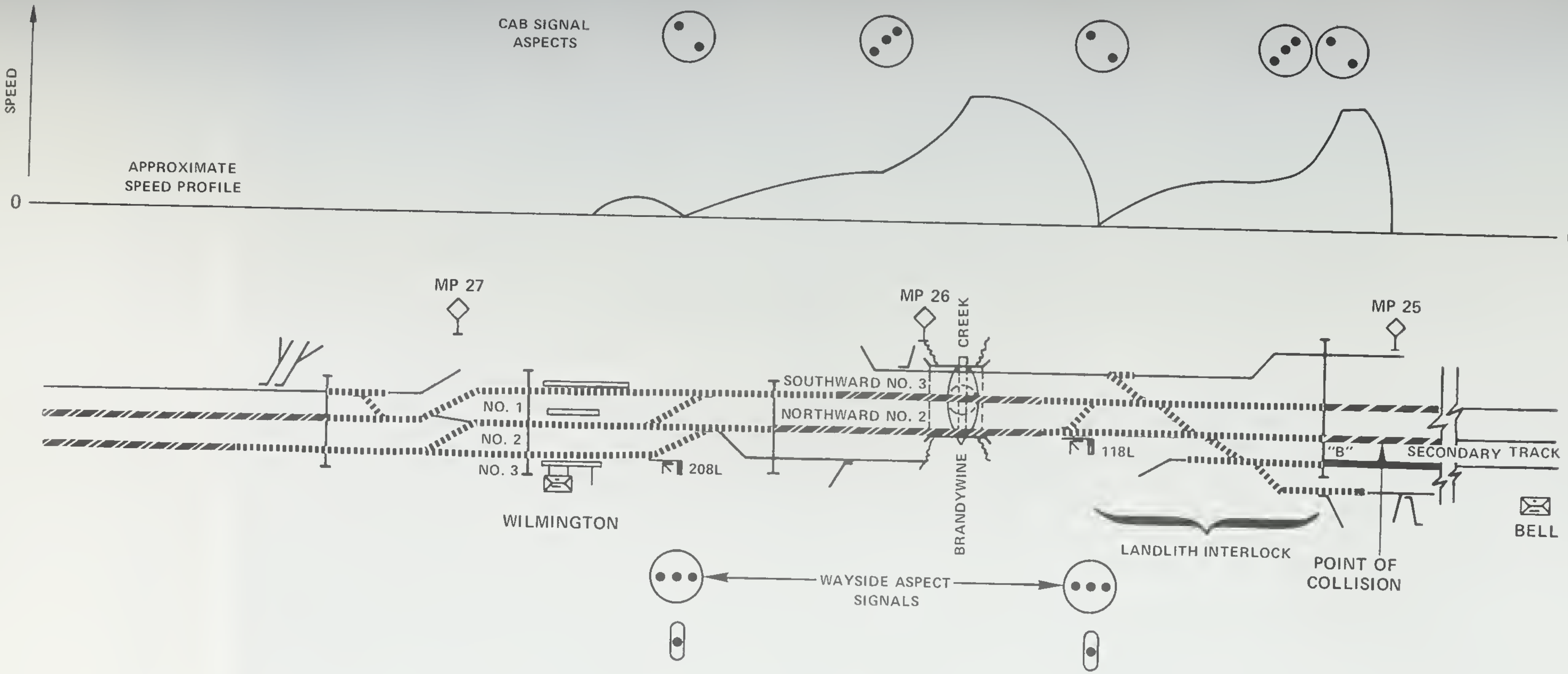


FIGURE 1
ACCIDENT SITE
METRO #132 AND MU #944



= Interlocking Rules 605 to 670

= Rules 261 to 264 Automatic Block Signal System Rules 501 to 514 Cab Signal Rules 550 to 562 } With and Against the Current of Traffic

= Automatic Block Signal System Rules 501 to 514 Cab Signal Rules 550 to 562 Rules 251-253-254 } With the Current of Traffic

Manual Block Signal System Rules 305 to 342 — Against the Current of Traffic

= Rule 110 - Spec. Instr. 1151-D1

FIGURE 2

TRACK PLAN VIEW MP 27 TO MP 25 INDICATING INTERLOCKING LAYOUT, SIGNAL LOCATIONS AND SPEED PROFILE. LIMITS OF APPLICABLE RULES ARE INDICATED.

The Trains

Characteristic	Train No. 132	Train No. 944	Train No.
No. Cars	6	5	6
Manufacturer	Budd	Budd	NM
Weight	165,000 lbs	102,000 lbs	NM
Length	85 ft	85 ft	NM
Collision Post Static End Load	800,000 lbs	800,000 lbs	NM
Locomotive Controls			
. Speedometer	#	X	NM
. Radio Phone	#	#	X
. Intercom	#	X	NM
. Cab Signal Equipment	#	#	NM
Maximum Operating Speed	105 mph	75 mph	65 m

\# present
X absent
NM not material

Damage to Trains and Track

Damage to train No. 132 amounted to $317,061, damage to train No. 944 amounted to $499,065, and damage to train No. 939 amounted to $1,760.

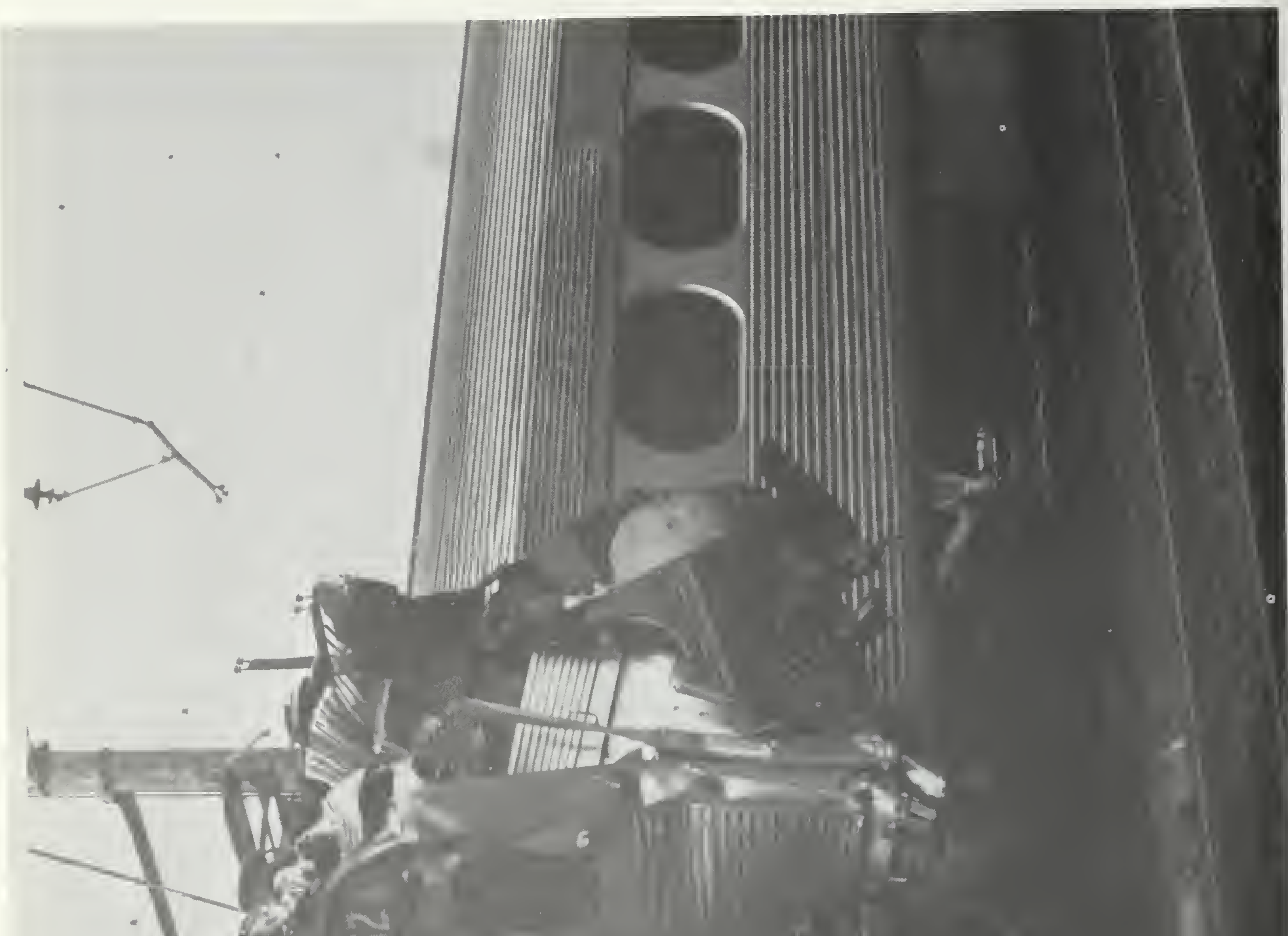
The lead car of train No. 944, No. 252, was damaged heavily; the forward portion of this car collapsed through the vestibule. The center sill of No. 252 underrode the last car of train No. 132, and the end sill and buffer structure of that car contacted and sheared No. 252's collision post. The second, third, and fourth cars of train No. 944 were damaged slightly.

Train No. 132 was not damaged as extensively as No. 944; the lead car on No. 944 had not penetrated the control or coach compartments on the last car of No. 132. (See Figures 3 and 4.)

Penn Central examined the cars to determine why the trailing car of train No. 132 was damaged less severely than the lead car of train No. 944. Their report stated: "...couplers on the two types of equipmen differ and are not compatible.

"On impact, the striking Silverliner cars deflected downwards as couplers passed permitting the draft sill of the Silverliner to enter the striker opening of the Metroliner. This in turn allowed the end sill and

Figure 3. Last car of No. 132.


252

buffer structure of the Metroliner to contact and shear the Silverliner collision post, resulting in collapsing of the vestibule of the Silverliner. Since the buffer of the Metroliner was pushing the end structure of the Silverliner away from its own striker, the contact between the end sheets of the Silverliner and the Metroliner was minimized, resulting in minimal damage to the Metroliner end."

Train No. 939's lead car, No. 686, was slightly damaged as it scraped protruding equipment. The train did not derail.

About 950 feet of the east rail of track No. 2 were damaged and about 440 feet of the west rail were damaged.

The Traincrews

The crew of No. 132 consisted of an engineer, a brakeman, a flagman, and a conductor. The engineer, the brakeman, and the flagman were hired in 1941. The conductor was hired in 1972, and he did not recall having received training concerning the priorities in his responsibilities during emergencies.

The crew of No. 944 consisted of an engineer, a conductor, and a flagman. The conductor and flagman were hired in 1941 and 1973, respectively. The engineer was hired in 1942. He was promoted to a locomotive engineer in 1946 and had worked in all classes of service throughout his 34 years with the railroad. His record contained a few minor infractions relative to his performance as an engineer.

The engineer had received a head injury when struck by an object thrown at his train in June 1973. The engineer did not work again until September 11, 1973, when a medical examination indicated that he was fit for service. He passed additional annual physical examinations on May 28, 1974, and on May 16, 1975. However, the engineer said that he requested assignments that were less arduous than normal assignments when he first returned to work. He stated after the accident that the injury had impaired his ability to concentrate.

Tests and Research

After the collision, the rail was examined to determine the point where the emergency brakes of No. 944 were applied. Although the condition of No. 944's wheels suggested heavy braking, the point where the braking began could not be established.

The wayside signaling system was examined after the accident and was found to be functioning normally.

Air brake tests were conducted and the brake systems were found to be functioning on the undamaged brake components of No. 944.

The air brakes on No. 132 were examined to determine what caused the brakes to apply in emergency. The examination showed that the alerter circuit breaker had tripped and also showed that the alerter magnetic valve's suppression diode was missing. The diode was designed to protect the alerter system against voltage spikes in the battery circuit.

The radios on No. 132 did not function after the accident. Investigators determined that the batteries used to supply power to the radio system in emergencies were inadequate. These batteries also had caused the failure of the emergency lights on some cars. When current was applie the marker lights on train No.132's rear car, No. 887, were operable.

Sight distance tests were conducted using cars similar to the collision cars to determine when the rear end of train No. 132 would have been visible from car No. 252, the lead car on train No. 944.

The tests showed that although the rear lights of No. 132 could be seen for more than 1,000 feet, they were not conspicuous. The tests also showed that because of the color of No. 132, it was relatively inconspicuc in reduced light.

Stopping distance tests and braking tests also were conducted. Durir the brake tests, the engineer of No. 944 was asked to estimate certain speeds. In the first test he was asked to operate his train at 10 mph. I accelerated the train to what he considered to be 10 mph and the radar indicated that the speed was 14.5 mph, almost 50 percent greater than the intended speed. When the engineer of No. 944 was asked to simulate his r from Wilmington to the accident site, his train speed was measured by a wayside radar instrument. The instrument measured his maximum speed at 42 mph.

ANALYSIS

The Accident

The engineer of No. 944 had seen No. 132 depart Wilmington Station. He often followed this Metroliner on close headways and expected that its progress would not be interrupted. This expectation was reinforced as th block signals governing the movement of his train indicated that No. 132 was progressing. The operator's message to inform him of the stalled Metroliner was not heard.

The engineer of No. 944 operated his train in compliance with the rules until he departed Landlith Interlocking. However, when the cab signal improved to "approach," indicating that the track ahead was unoccupied, he immediately placed his throttle in the full-power position which did not comply with the delay requirement specified in Rule 551(e). He should have waited at least 18 seconds for his train to run its full length before he increased speed.

The "approach" indication was the indication that the engineer would have received if No. 132 already had cleared the block limits controlled by signal 118L and was the same indication that he had received in his approach to 118L when No. 132 had cleared the interlocking limits. At this point, the engineer assumed that No. 132 had cleared the block limits of 118L and that the track ahead was no longer occupied. The Safety Board could not determine why conflicting cab signals were displayed. However, the depositions taken by the Safety Board indicated that the cab signals are not always reliable. There was no indication that cab signals had failed in this area before or after the accident.

After the engineer applied power, the cab signal immediately returned to the "restricting" aspect. Although required by Rule 551(d) the engineer did not immediately reduce his throttle and return to restricted speed nor did he call the indication to the trainman in the cab. He did not respond immediately because its return to the "restricting" aspect was unexpected.

The engineer's ability to see No. 132 was impaired seriously by the rain and the lighting conditions which existed at dusk. The effectiveness of No. 132's marker lights was diminished because there was still some natural light, and at the same time No. 132's silver-colored rear car was being obscured by the fading light. The Safety Board could not determine whether the engineer's earlier injury contributed to his failure to respond immediately to Rules 551(d) and (e).

Based on speed tests, by the time the engineer detected the standing train, his train's speed was probably more than 30 mph. His train's speed should not have exceeded 15 mph at that time. However, the operator was not informed of the derailment or of the obstruction to the adjacent track in sufficient time to implement Rule 627.

The Safety Board pointed out the benefits of train radios in its accident report concerning a 1970 collision between a passenger train and derailed freight cars in Soundview, Connecticut. 2/

Operating Procedures

Almost every rear end collision investigated by the Safety Board that has not been caused by a signal failure or by the physical impairment of crewmembers has been related to incorrect action under the restricted speed rule. The Safety Board has questioned the appropriateness of the procedures which allow a train to move into occupied blocks and has called for a review of these procedures. 3/ This accident again demonstrates that no train should be authorized to move into an occupied block.

2/ "Penn Central Transportation Company, Freight Train Derailment-Passenger Train Collision With Hazardous Material Car, Sound View, Connecticut, October 8, 1970."

3/ "Collision of two Penn Central Commuter trains at Botanical Garden Station, New York City, January 2, 1975." NTSB-RAR-75-8.

Contributing to the violation of the restricted speed rule in this case was the lack of a speed indicator on train No. 944; the crew had to estimate the train's speed. During one test performed after the accident, the engineer underestimated his train's speed by almost 50 percent. The Safety Board previously has called for the installation of speed-indicating and -recording devices on trains. 4/

Rule 99 required that if a train stopped under circumstances in which it might be overtaken, the crew should provide flag protection. However, it did not apply if the movement of trains was governed by automatic block signal system rules or by traffic control system. This exception to Rule 99 should be eliminated.

The failure of the railroad's operating system to warn train No. 939 of obstructions as it approached the accident site 12 minutes after the collision illustrates that the control of trains on adjacent tracks is not insured by current procedures and that Penn Central's safety system should be reexamined. They flagging of the adjacent track was not performed in accordance with Rule 102, probably because of the confusion at the collision site. Employees that should have flagged were assisting passengers. The crewmembers who could have flagged were either injured or were unable to find the necessary equipment. The absence of flagging equipment indicates that the current practice of predeparture checks cannot be relied upon to assure that such vital equipment is available.

The crew of No. 944 evacuated the cab seconds before it collapsed inwardly because the engineer knew that the cab of this type of car would collapse in collisions. This action undoubtedly prevented serious injury or death. The postaccident examination of the cab compartment indicated that the area was probably not survivable. The crewmember of No. 132 who did not evacuate the cab was not injured because the metroliner cab did not collapse; crewmembers should be instructed to evacuate when a collision is imminent.

Conspicuity of No. 132

No. 132 lacked conspicuity under the lighting conditions encountered at the time of the collision. The Safety Board already has recommended that the conspicuity of the rear ends of trains be improved. 5/ In response to these recommendations, the Federal Railroad Administration (FRA) is studying colors and methods of illumination to determine which will most improve the conspicuity of trains. The FRA intensified this study

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4/ Ibid.

5/ National Transportation Safety Board, "Collision of Illinois Central Gulf Railroad Commuter Trains, Chicago, Illinois, October 30, 1972." NTSB-RAR-73-1.

after an accident in Chicago, Illinois, which resulted in 45 fatalities and hundreds of injuries. 6/ The Safety Board believes that a Federal Standard for conspicuity of trains is warranted. 7/

Communication System

The trains' communication systems failed in accident. First, the engineer of No. 944 did not overhear the notification by the engineer of No. 132 to the operator that his train was stopping nor did he receive the notification from the operator that No. 132 had stopped. This information was important to the engineer of No. 944's evaluation of the track ahead. However, the system did not require that such information be conveyed to engineers entering occupied blocks. Had the engineer of No. 944 been notified before his train entered restricted block 118L, he probably would not have acted immediately on the false "approach" signal, and he probably would have reacted promptly when his cab signal indication changed to "restricting."

Second, the traincrews attempted to radio authorities after the first collision, but the radios on both trains were not operable. Had they been operable the crews could have insured that trains approaching the area were stopped; also, any traincrews on opposing tracks would have received more timely information about the collision had they been tuned to the same radio frequency.

Crashworthiness

Cars within the two trains did not override because the design of the couplers was adequate to withstand the forces of the collision. However, the contacting cars did override. When the trains collided the rear car of No. 132 withstood the impact forces, but the lead car of No. 944 did not.

Little is known about the crash dynamics of rail commuter cars, primarily because few of them have been involved in collisions. This collision illustrates what can be expected when commuter trains collide with Metroliners. Had the impact speed been greater, the couplers on No. 132 probably would have penetrated the coach compartment on the lead car of No. 944 and the injuries to persons in the coach compartment probably would have been more severe. The difference in the behavior of these cars in the crash environment indicates that rail commuter cars should be studied to determine how their crashworthiness can be improved.

6/ Ibid.

7/ FRA is considering the comments filed in response to a Notice of Proposed Rulemaking (NPRM) proposing issuance of a regulation to require highly conspicuous marking of the rear end of passenger trains and has devoted considerable effort in field testing of strobe lights and other devices under typical operating conditions. In the course of this field testing, deficiencies in the system proposed in the NPRM were uncovered. FRA is now engaged in developing a second NPRM, which will invite public comment on a modified system.

Maintenance Procedures

When No. 132 was examined to determine what had caused its brakes to apply in emergency, investigators discovered that the suppression diode in the alerter circuit breaker was missing. If the suppression diode had been in place, the train would not have stopped. Investigators also determined that the batteries which powered the radios and the emergency lights were run-down.

The Penn Central does have a program to replace all existing batteries on Metroliner cars; consequently the batteries on No. 132 would have been replaced eventually. However, the Safety Board believes that the lack of both a suppression diode and the inadequate power indicate that the maintenance procedures of the Penn Central should be reviewed.

Safety Management

This accident indicates that railroad mangement needs to:

- o Improve maintenance and quality control of its railroad system, e.g., the ommission of a diode in the Metroliner alerter, the variable performance of the cab signals.
- o Assure that flagging equipment is available on all trains.
- o Improve personnel training in emergency procedures.
- o Assure the operational performance and readiness of communication channels and operationsl practices.
- o Provide clear and concise instructions which employees can use to determine the priorities of their duties in emergency situations.

CONCLUSIONS

1. Train No. 132 was stopped in emergency because the alerter circuit breaker tripped.
2. The absence of the suppression diode across the alerter magnet valve was responsible for the unplanned stop.
3. The engineer of No. 944 did not hear the message that No. 132 had stopped.
4. The cab signals of No. 944 provided unreliable information about the condition of the block in which No. 944 was operating when the cab signal displayed an "approach" aspect although the track ahead was occupied.

5. The engineer of No. 944 accelerated his train immediately in violation of Rule 551(e), and did not react immediately to the restricted signal aspect.

6. Speedometers are necessary to assure rule compliance.

7. The speed of train No. 944 probably reached 30 mph while operating with a restricted cab signal indication displayed instead of the 15 mph or less required by Rule 551(d).

8. Although the marker lights on the rear of No. 132 were lit the conspicuity of the train was poor under the existing environment conditions and the engineer of No. 944 did not see No. 132 in time to stop.

9. The failure of the communication and lighting systems after the accident was due to run-down batteries.

10. The crew of No. 132 should have provided flagging immediately after the collision.

11. Operating Rule 291 should be changed to prevent trains from entering occupied blocks and Rule 99 should have the exception concerning flagging in automatic block signal territory eliminated.

12. The crash damage indicated that trains No. 132 and No. 944 were incompatible in a crash environment.

13. Safety management practices of Penn Central were not adequate.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the rear end collision was the engineer's failure to operate his train according to established procedures. Contributing to the accident was the operational practice of the railroad industry which permits trains to enter occupied blocks. The second collision was caused by the absence of flagging.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board made the following recommendations to the Federal Railroad Administration:

"Establish regulations on mainlines used by passenger trains that will require trains to stop if the block in front of them is occupied. (R-76-24) (Class II, Priority Followup)

"Establish standards for rear end visibility of trains. (R-76-25) (Class II, Priority Followup)

"Require that trains are equipped with emergency flagging equipment. (R-76-26) (Class II, Priority Followup)

"Establish regulations for the protection by flagging of the rear end of all stopped trains in passenger territory. (R-76-27) (Class II, Priority Followup)

"Require carriers to provide emergency lighting and communication systems on passenger cars and to provide for predeparture inspection to assure their operability. (R-76-28) (Class II, Priority Followup)

"Require carriers to train employees in emergency procedures to be used after an accident, to establish priorities for emergency action, and to conduct accident simulations to test the effectiveness of the program, inviting civic emergency personnel participation. (R-76-29) (Class II, Priority Followup)

"Require railroads to include emergency procedures for cab evacuation in its training program for operating employees. (R-76-30 (Class II Priority Followup)

"Observe a statistically adequate sample of trains equipped with cab signals to establish the reliability of this system. Appropriate remedial action should be taken based on these findings. (R-76-31) (Class II, Priority Followup)

"Require that trains be equipped with reasonably accurate speed indicators. (R-76-32) (Class II, Priority Followup)

The Safety Board made the following recommendations to the Consolidat Rail Corporation:

"Study the recommendations made to the Federal Railroad Administratic in this report and take immediate appropriate action. (R-76-33) (Class II, Priority Followup)

"Require that trains be equipped with reasonably accurate speed indicators. (R-76-32) (Class II, Priority Followup)"

The Safety Board made the following recommendations to the Southeaster Pennsylvania Transportation Authority and AMTRAK:

"Include in your agreements with Consolidated Rail Corporation (Con Rail) requirements that will provide for the safe transportation of passengers as well as for their protection and care in the event of an accident. (R-76-34) (Class II, Priority Followup)

"Require that trains be equipped with reasonably accurate speed indicators. (R-76-32) (Class II, Priority Followup)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

June 16, 1976

NATIONAL TRANSPORTATION SAFETY BOARD
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RAILROAD ACCIDENT REPORT

CHICAGO TRANSIT AUTHORITY COLLISION OF TRAINS NO. 104 AND NO. 315 AT ADDISON STREET STATION

CHICAGO, ILLINOIS

JANUARY 9, 1976

REPORT NUMBER: NTSB-RAR-76-9

UNITED STATES GOVERNMENT

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On January 9, 1976, at 8:06 a.m., Chicago Transit Authority (CTA) train No. 315 struck the rear end of train No. 104 while it was standing at the Addison Street Station platform in Chicago, Illinois. The impact forces extensively damaged the lead car of the moving train and the rear car of the standing train, and slightly damaged the other cars in both trains. Damage to the equipment and track was estimated to be $267,000. Of the 381 passengers who were injured in the collision, 1 passenger died.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the motorman of train No. 315 to perceive standing train No. 104 at a sufficient distance to permit him to stop his train before striking No. 104. Contributing to the collision were the rule that permitted the operation of the train with the automatic train control and the cab signals inoperative, the lack of consistent enforcement of operating rules, the absence of flag protection against following trains, the failure of the train phone system to provide reliable communications, and the violation of the 25-mph speed limit required by Rule 178B.

As a result of its investigation of the accident, the Safety Board issued seven recommendations to the Chicago Transit Authority and three recommendations to several major metropolitan transit authorities.

17. Key Words Rapid transit; electrification; third-rail; circuit breaker; train phone; cab signals; automatic train control; flagging; training program; rules; rescue forces; motorman; conductor; controller; rail service supervisor; instructor.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.	
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FOREWORD

This report is based on an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: July 8, 1976

CHICAGO TRANSIT AUTHORITY COLLISION OF TRAINS NO. 104 AND NO. 315 AT ADDISON STREET STATION, CHICAGO, ILLINOIS JANUARY 9, 1976

SYNOPSIS

On January 9, 1976, at 8:06 a.m., Chicago Transit Authority (CTA) train No. 315 struck the rear end of train No. 104 while it was standing at the Addison Street Station platform in Chicago, Illinois. The impact forces extensively damaged the lead car of the moving train and the rear car of the standing train, and slightly damaged the other cars in both trains. Damage to the equipment and track was estimated to be $267,000. Of the 381 passengers who were injured in the collision, 1 passenger died.

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FACTS

The Accident

On January 9, 1976, at 7:59 a.m., a southbound Chicago Transit Authority (CTA) train, No. 104, departed Jefferson Park Station en route to the downtown area of Chicago, Illinois. Train No. 104 consisted of six 6000-series cars, Nos. 6599-6600, 6050-6049, and 6584-6583. The crew consisted of a motorman and a conductor. As the

train came into the Addison Street Station, the motorman saw a blue light, which indicated that a circuit breaker had been actuated on his train, illuminate on his display panel. He operated a reset button to close the open breaker and the blue light went off, but it illuminated again when he applied power to the train. He attempted to notify central control by train phone that the circuit breaker had actuated, but he did not receive a response. He coasted the train into the station and attempted to call central control again, but still he did not receive a response. He then stepped out on the platform to inspect the cars in the train, to determine on which car the circuit breaker had actuated, and to open that car's seven-point switch. 1/ He did not advise the conductor to protect the rear of the train because he had not been required to do so under such circumstances.

Southbound CTA train No. 315 was scheduled to depart Jefferson Park Station at 7:58 a.m. The train consisted of four 2200-series cars, Nos. 2308-2307 and 2304-2303. The crew consisted of a motorman and a conductor. (See Appendix A.) When the motorman entered the operating compartment of his train, he noticed that the seal on the bypass button's shield had been broken. He inserted his key into the control panel to activate the controls, and he heard a "steady audible" tone, which indicated that the automatic train control (ATC) equipment was not functioning properly. In accordance with CTA rules, the motorman attempted to notify central control of the failure and to receive instructions, but he did not receive a response from central control. The motorman left the train and went to a yard telephone to call the rail service supervisor at Jefferson Park so that the supervisor could instruct him on the proper course of action. The yard foreman at Jefferson Park answered the phone and relayed the motorman's message to the rail service supervisor, who authorized the motorman, through the yard foreman, to bypass the ATC equipment and to operate the train in the bypass mode. The motorman accepted this authority from the yard foreman, who was not authorized to give it; he returned to his train and used the bypass button to pull the train to the station. The passengers boarded the train and it departed at 8:03 a.m., 4 minutes behind train No. 104.

1/ A "seven-point" switch isolates the propulsion system of a car from that of the other cars in the train.

Train No. 315 made its first scheduled stop at Irving Park Station without encountering any difficulty and continued southward at 30 to 35 mph toward the Addison Street Station; No. 315 was not scheduled to stop there, but was to continue to Belmont Avenue Station. The motorman was familiar with the schedule of No. 104 and he expected that No. 104 had departed Addison Street Station, so he was not prepared to stop at Addison Street. The motorman later stated that he did not see standing train No. 104 because the sun had blinded him. The sun was on an azimuth of 130^{o}, about 7^{o} or 8^{o} above the horizon at that time, so the motorman was facing the sun.

When the motorman finally saw train No. 104, he immediately released the bypass button so that the brakes would apply in emergency and he moved the cineston control to apply the magnetic track brakes. However, the train did not stop or slow appreciably. Train No. 315 collided with the rear of train No. 104 at 8:06 a.m.

The anticlimber of train No. 315 struck the anticlimber of train No. 104 and neither car overrode the other. Train No. 104 was pushed about 100 feet, or 2 car lengths; train No. 315 separated from train No. 104 and stopped about 65 feet from the rear of train No. 104. Of the 381 passengers who were injured in the collision, 1 died.

Postaccident Activities

The motorman of train No. 104 attempted to notify central control of the collision by train phone, but he received no response, so he left the train and went to the ticket window in the station to get the agent to call for help. The ticket agent already had called for assistance, so the motorman returned to his train. The motorman of train No. 106, which was following train No. 315, heard the motorman on train No. 104 when he called central control on his train phone. When the motorman of train No. 106 did not hear an answer to that call, he also attempted to reach central control, but his call was not acknowledged.

The motorman of train No. 315 remained in the operating compartment of his train during the collision; although he was knocked down when the trains collided, he was not injured. He left the operating compartment through a broken side window and moved across the front of the train to the station platform. When he could not open the side car doors, he boarded the train between the first and second cars and entered the first car through the end door to begin assisting the passengers. The two conductors remained in their trains to assist the

passengers. The conductor of train No. 315 did not provide flag protection to the rear of his train.

Most of the injured passengers were able to detrain themselves when the doors of the trains were opened; however, a few were evacuated on stretchers. The injured were transported to 13 hospitals.

Accident Site

The trains collided on the West-Northwest line, of which Jefferson Park is the northern terminus. The West-Northwest line consists of a northbound track and a southbound track. A third rail, which is the power source, parallels each track. The station at Addison Street is located between the northbound and the southbound tracks. About 1,500 feet north of Addison Street Station is an overhead bridge. (See Figure 1.)

South of Irving Park Station, the track's grade is 2.5 to 3 percent descending. As the track approaches the overhead bridge, it enters a $1^{\circ}34' 45''$ left curve, which continues southward for about 760 feet. The track is straight for 50 feet and then it enters a $4^{\circ}24'45''$ curve to the right; the curve extends through the station area, where it gradually reduces to a $0^{\circ}47'45''$ curve. The grade changes from a descending to an ascending grade about 275 feet north of the point of impact. As the track approaches Addison Street Station, it lies on a bearing of about 12° from north. (See Figure 2.)

The 144-pound third rail supplies 600 V.d.c. of propulsion power to the trains. Conventional sliding shoes on the self-propelled cars pick up the power. The power section in which the trains collided is designated as No. 314. It is fed from Kedvale substation, north of Addison Street, and Sacramento substation, south of Addison Street.

The third rails have protective circuit breakers that are actuated when the breakers are overloaded instantaneously or when the demand for power is prolonged and heavy. When the fault-detection device which monitors the system detects no fault after the circuit breakers actuate, the circuit breakers will reclose in 8 seconds. If a fault persists for more than 30 seconds, the circuit breaker will lock open and power will remain off.

The power supervisor's log shows that on the day of the accident, the circuit breaker for section No. 314 at Kedvale substation opened

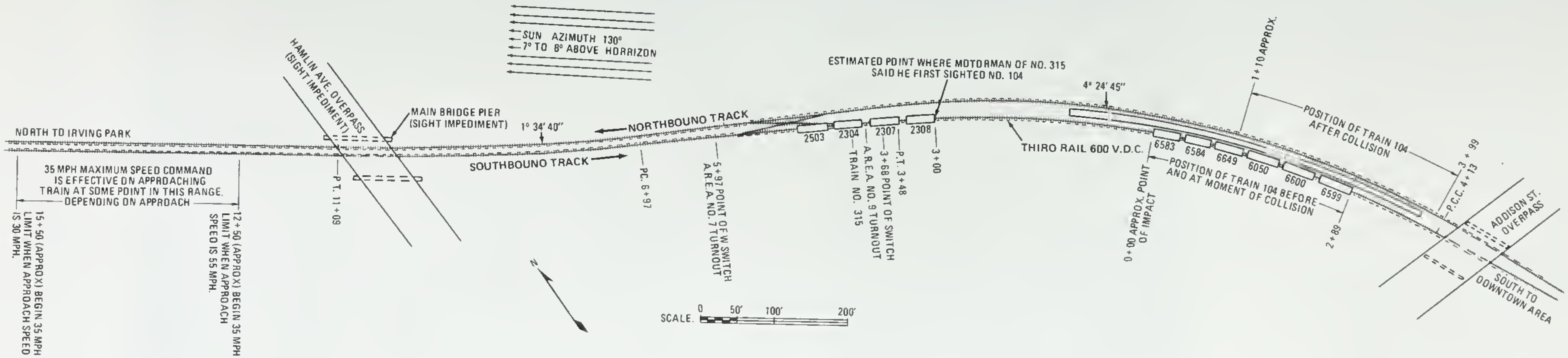

Figure 1

ACCIDENT SITE
Collision of Trains No. 104 and No. 315
ADDISON ST. STATION
CHICAGO, ILLINOIS
8:06 A.M. JANUARY 9, 1976

Figure 2. Approach to Addison Street Station, 1,100 feet north of the point of impact. Station and train are visible.

and closed automatically at 8:03 a.m. and the circuit breakers at Kedvale and Sacramento substations opened and closed at 8:06 a.m. At 8:20 a.m., CTA supervisory personnel at the scene requested that power on Section No. 314 be turned off during rescue operations.

On the day of the accident, the weather was bright and clear and visibility was unlimited. The temperature was about 3°F.

Method of Operation

Trains are operated over the West-Northwest line by bulletin orders, automatic block signals and cab signal indications, and ATC. Cab signals and ATC are in operation from Jefferson Park southward through the area of Addison Street. The speed limit is 55 mph.

The CTA operating employees are governed by a rulebook which became effective on October 1, 1962. CTA management no longer enforces several rules in the rulebook. Also, the responsibilities and titles of several supervisors have changed, but the rulebook has not changed accordingly.

The Department of Transportation has authority under the Railroad Safety Act of 1970 to regulate safety of the CTA operation; however, the only Federal regulations which apply to the CTA operations relate to the reporting of accidents. The Urban Mass Transportation Administration (UMTA) has authority to require safety in areas which are funded by UMTA grants. The Occupational Safety and Health Administration exercises some control in matters related to occupational safety and health, but these controls do not apply to CTA train operations. The State of Illinois has no authority over the CTA because it is a corporate structure which is owned by a municipality. The Chicago Regional Transit Authority (RTA) has authority under its charter to regulate and control the CTA, but at the time of the accident, the RTA had not exercised this power. (See Appendix B.) The CTA is virtually self-regulating.

ATC System--When a train enters a block, cab signal and ATC information is fed into the track at the opposite end of the block. This is done with an audio frequency (AF) overlay system which can signal four speed conditions, depending on the occupancy of the block. The AF signal is picked up from the rails by receiver coils which are attached to the front of the motor unit. Carborne logic circuits analyze the information and cause the proper cab signal indications to be displayed, and they establish the maximum allowable speed in the ATC

speed-control equipment. The Aspect Display Unit (ADU) displays both the cab signal for the current block condition and the maximum allowable speed by means of a progressive light bar above the speedometer.

At certain locations, such as at curves or past a station platform, speed restrictions are programmed into the wayside logic in cab signal territory so that the speed restrictions are imposed and enforced automatically.

In a normal operational mode, the motorman must keep his train's speed below the maximum allowable speed indicated by his cab signal. If he exceeds that speed, a warning tone sounds and he has 2.5 seconds to move his cineston control lever to a predetermined braking position (B-2 or B-3). 2/ He must maintain the B-2 or B-3 position until the train's speed is reduced to the allowable speed. If the motorman does not reduce the train's speed within 2.5 seconds, the train will be braked automatically to a stop.

If the ATC becomes inoperative, either the train cannot be moved at all or it must be operated at a reduced speed. To overcome these problems, a bypass button is provided on the ADU. The bypass button bypasses the ATC and nullifies its safety features; it also bypasses the side-trip emergency brake switch, the conductor's and the motorman's emergency brake switches, and the magnetic track brakes. The cab signal indications may still be operative and provide an indication of the track or block conditions ahead, but in the bypass mode, vital circuits and safety circuits in the ATC equipment are bypassed and the reliability of the cab signal indications is questionable.

During 1975, ATC systems failed an average of 6.5 times a day and caused the trains to be operated in the bypass mode. During this same period, the ATC equipment in one of the sets of cars in train No. 315--Nos. 2307-2308--failed 25 times, and the bypass button had to be used in order to operate the cars.

The CTA maintenance program for the ATC is based on mileage. Each 6,000 miles, the ATC equipment is tested according to a test procedure recommended by the equipment manufacturer; the equipment is checked to verify that cab signal indications for a given block condition and the maximum allowable speed are correct.

2/ Degrees of dynamic braking.

Normally, the ATC bypass button is covered by a protective metal shield and is sealed closed by a lead-wire seal. Before the January 9, 1976, collision, motormen were required to contact a supervisor for permission to break the seal so that the bypass button would be accessible. (See Figure 3.) The motorman was required to give the authorizing supervisor his name and badge number and the supervisor was required to give the motorman his name and badge number and to read him the visual operating rule. Each was required to fill out a report form to give the designated officer all pertinent information. Although the rail service supervisor had been authorizing motormen to operate in the bypass mode, the actual authority rested with the controller. The controller was required to fill out the report and to take other necessary action to dispose of the malfunctioning equipment.

Once the procedure prescribed by the rules was followed, the motorman could depress the bypass button and move his train. The motorman had to hold the button depressed with one hand and hold the deadman control on the cineston control lever with the other to keep the train in motion. While the motorman was operating in this manner, he was required to maintain an awkward stance while the train was moving. (See Figure 4.) Whenever the ATC malfunctioned, it emitted a constant tone. Operating the bypass button did not stop the tone or cause the lights in the ADU to extinguish. However, the ADU of motor unit 2308 of train No. 315 was dark when the train began its run.

When a motorman operates a train in the bypass mode, he is required to operate under the visual rule, which states: "Operate 'on sight' at speeds which will permit the train to be stopped within the distance the track can be seen to be clear. The maximum speed when operating on the By-Pass is 35 mph." When visibility is reduced the visual rule is superseded by Rule 178B, which states, "In cases of reduced visibility or on curves, Motorman is authorized to operate at the posted speed not to exceed 25 M.P.H. maximum."

There are no requirements that the ATC, cab signals, or train phone be tested before a train departs its terminal. No advice is issued to employees along the route if any of these fail or begin to malfunction.

The day after the accident, the CTA issued special instructions to prohibit a train from leaving a terminal with the ATC inoperative. The instruction also gave the course of action to be followed when the ATC failed en route. (See Appendix C.)

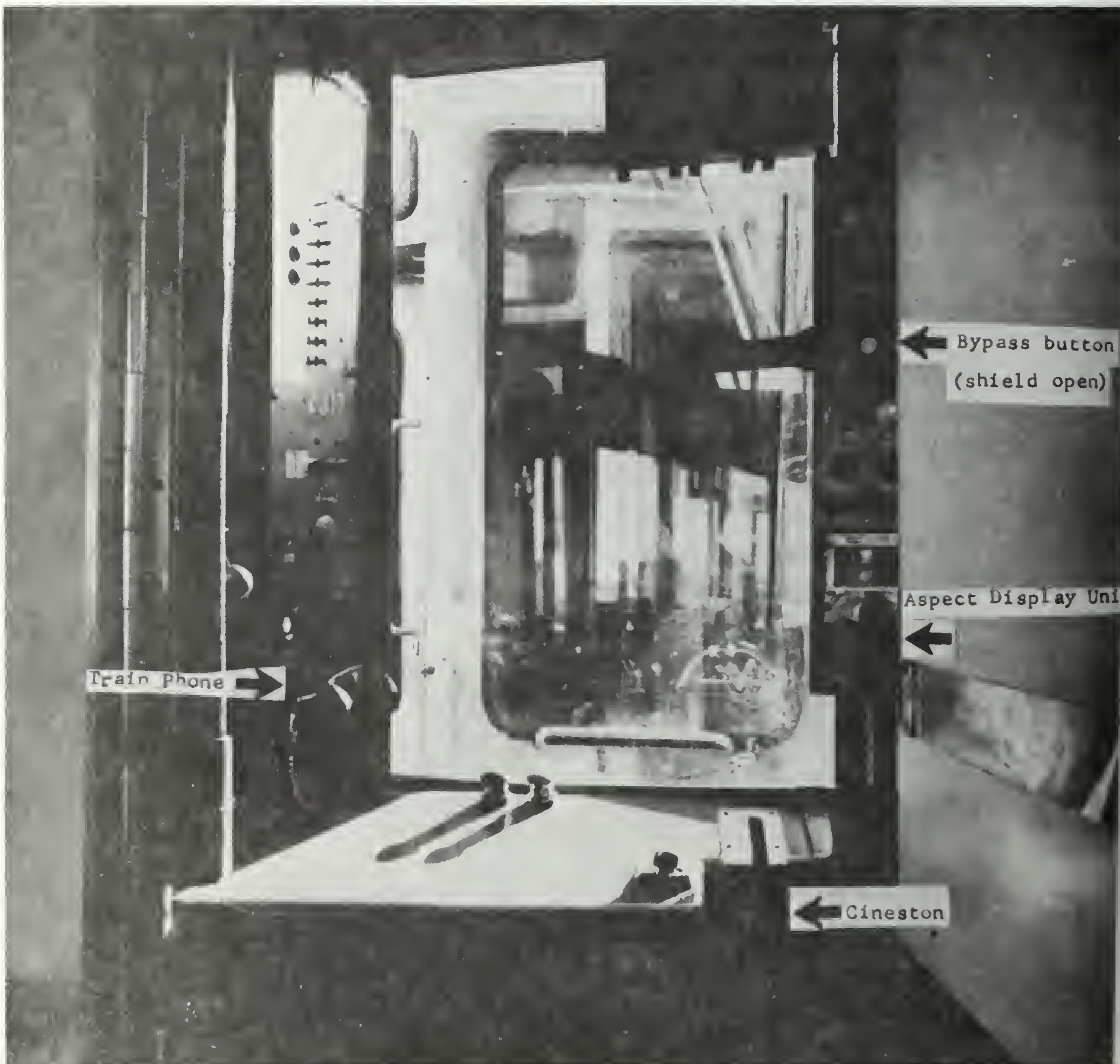

Figure 3. Aspect Display Unit and a general view of the motorman's cab.

Figure 4. Stance of motorman of train No. 315 as he operated in the bypass mode.

Train Phone Communication System--All trains are equipped with a train phone to communicate with the controller in central control and with other trains. The 6000-series cars, such as those in trains 104 and 106, use a portable train phone set which a crew picks up at the beginning of each trip. The 2200-series cars, such as those in train No. 315, have train phones installed.

The train phone uses the third rail and the running rails as communication paths. Transceiver amplifiers are placed selectively along the route to boost the signal. A pickup system through the sliding shoe contactor on the third rail completes the circuit to the rails.

Supervisory Personnel--A rail service supervisor at Jefferson Park Station has jurisdiction over all operating employees on the West-Northwest line. His booth at the station is equipped with the CTA system telephone, an intercom to the yard foreman, and an intercom to the superintendent. When the controller delegates the responsibility to him, he determines the spacing between departing trains. At the time of the accident, he could authorize the operation of trains in the bypass mode based on his own judgment and he could authorize the switching or the interchanging of equipment to fulfill the service requirements.

The rail service supervisor who was on duty on January 9, 1976, stated that he authorized train No. 315 to operate in the bypass mode because: (a) He had no spare equipment available, (b) the train was in a lead track in the yard and was blocking other outbound equipment, (c) it would have taken a minimum of 12 minutes to have switched the units so that unit 2308 would have been a trailing unit, (d) the trains already were running behind schedule, (e) the weather was near $0^{o}F$ and there were several hundreds of passengers to move, and (f) he knew that the performance record of the motorman was good and he was sufficiently impressed with it to allow it to influence his decision.

When he authorized the motorman to operate without the ATC, he did not exchange the required information with the motorman and he did not read the motorman the visual operating rule.

A CTA controller, who has jurisdiction over the operating employees and the operation of the trains, monitors the passage of trains past selected reporting points by observing the marking of a time synchronized chart. Normally, he starts the trains from Jefferson Park, but during rush hours, he frequently delegates this task to the rail service supervisor.

The controller can communicate directly with the trains by train phone. When trains experience trouble or are delayed, the motorman is supposed to contact the controller to receive directions. The controller is required to alert trains of dangerous situations, to direct rerouting of trains, and to direct emergency operations. The controller who was on duty on January 9, 1976, said that he did not hear trains No. 315, No. 104, or No. 106 call him, although he did hear some noise.

The CTA designates some supervisory personnel as instructors to check the efficiency of operating personnel. They ride trains to observe operating practices and they question employees relative to certain rules or requirements. When an employee does not understand a rule or he violates proper operating procedures, the instructors insure that the employee is instructed in the areas in which he is deficient.

The CTA recently consolidated all safety functions into one department, which reports to a Manager of Safety. This safety department is in the formative stage; it is being designed to participate in all matters which concern the design and procurement of equipment, operating rules, and training programs. The safety staff operates only in an advisory capacity; although it may recommend safety improvements, it has no authority to order compliance with a rule or to institute a change. The Manager of Safety was not consulted in the formulation of new instructions which were issued after the accident.

Training of Employees--The CTA has a training program for all operating employees. When an employee is hired, he must attend a minimum of 2.5 days of classroom instruction and then spend 3.5 days in on-the-job training in order to qualify as a conductor. He must qualify as a flagman within 30 days of the date on which he qualified as a conductor. To advance to motorman, he must attend classes for 4 days, spend 3 days in on-the-job training, spend 60 hours in supervised motor operation, and pass written, oral, and operating tests. A motorman can progress to switchman or towerman under the respective scheduled training program. All employees are required to progress through this series of jobs. The CTA offers refresher training, and supervisors and instructors constantly monitor traincrews and other operating employees. CTA considers this sytem an acceptable substitute for an annual or periodic reexamination.

The Trains

The trains of the CTA consist of two-car sets that are connected semipermanently by energy absorption couplers. Train No. 104 was

composed of three such sets and train No. 315 was composed of two sets.

The cars on train No. 104 were manufactured by the St. Louis Car Company about 1950. The train weighed about 312,000 pounds. The underframes of the cars were designed to withstand a 100,000-pound force applied over a 4- by 24-inch area of the face of the anti-climber. The anticlimbers were fastened to the end sill at each end of the car. The end posts were attached to absorb energy by yielding and deforming rather than by breaking away from their attachment to the frame. The interior of the cars had cushioned seats which faced both ends of the cars. The seat backs were steel plates which were enclosed by tubular steel frames and were covered with a light padding. Tubular steel frames across the top of the seatback served as handhold Vertical stanchions were located at the doors and at several seat locations throughout the car. There were two doors on each side of the car which were located about 1/4 car length from the end.

The cars on Train No. 315 were manufactured by the Budd Company in 1969 and 1970 and were similar to those in train No. 104. The underframes of the cars were designed to withstand a 200,000-pound force applied over a 4- by 24-inch area on the face of the anticlimber. The height of the anticlimbers was compatible with those of train No. 104.

The equipment of both trains was propelled electrically by tractior motors on each car. The primary braking mode was dynamic. The drive shaft of each car had a friction brake that automatically operated below 5 mph and in emergency braking; the cars also had magnetic track brakes that could be used in emergency stopping.

Car 2308 was the lead car of a train which arrived at 54th Street Yard at 12:14 a.m. on January 9, 1976. Nos. 2308-2307 were couplec to Nos. 2304-2303 to be operated northbound as train No. 316; the train departed about 7:04 a.m. with Nos. 2308-2307 as the trailing uni When train No. 315 arrived at Jefferson Park, car 2308 became the lead car of train No. 315. Personnel who handled car 2308 reported that everything was functioning normally during the time that they wer operating it and that the bypass button shield was closed and sealed properly. It was never determined how or when the seal was broken.

Damage to Trains

When train No. 315 struck train No. 104, the anticlimbers engaged and prevented the cars from overriding each other. The two cars jumped up momentarily and derailed. It was probably during this action that the circuit breakers were actuated. Shear pins in the couplers of most of the cars sheared and the ends of the two striking cars were crushed. The anticlimbers within each train were deformed.

The frames and end posts of the two striking cars were deformed; this reaction absorbed much energy. The crush deformation was evident on car 2308 for about 3 feet and on car 6583 for about 7 feet. The damage to both cars was predominantly at floor level. The deformation was most severe near the points of impact and decreased progressively as the forces which penetrated farther into the cars were attenuated. (See Figures 5 and 6.)

Injuries to Passengers

Most of the passengers were treated in emergency rooms and released, but 64 were hospitalized. Some passengers walked into hospitals later with complaints of injuries which they had received in the accident.

Injury data were collected for 342 of the 381 passengers who were injured. A summary of their injuries according to the American Medical Association's Abbreviated Injury Scale (AIS) is as follows:

Severity of Injury	Number of Passengers
Minor	312
Moderate	19
Severe (not life-threatening)	7
Serious (life-threatening, survival probable)	3
Critical (survival uncertain)	-
Fatal	1
Total	342

Figure 5. Train No. 315, Car 2308, after the impact.

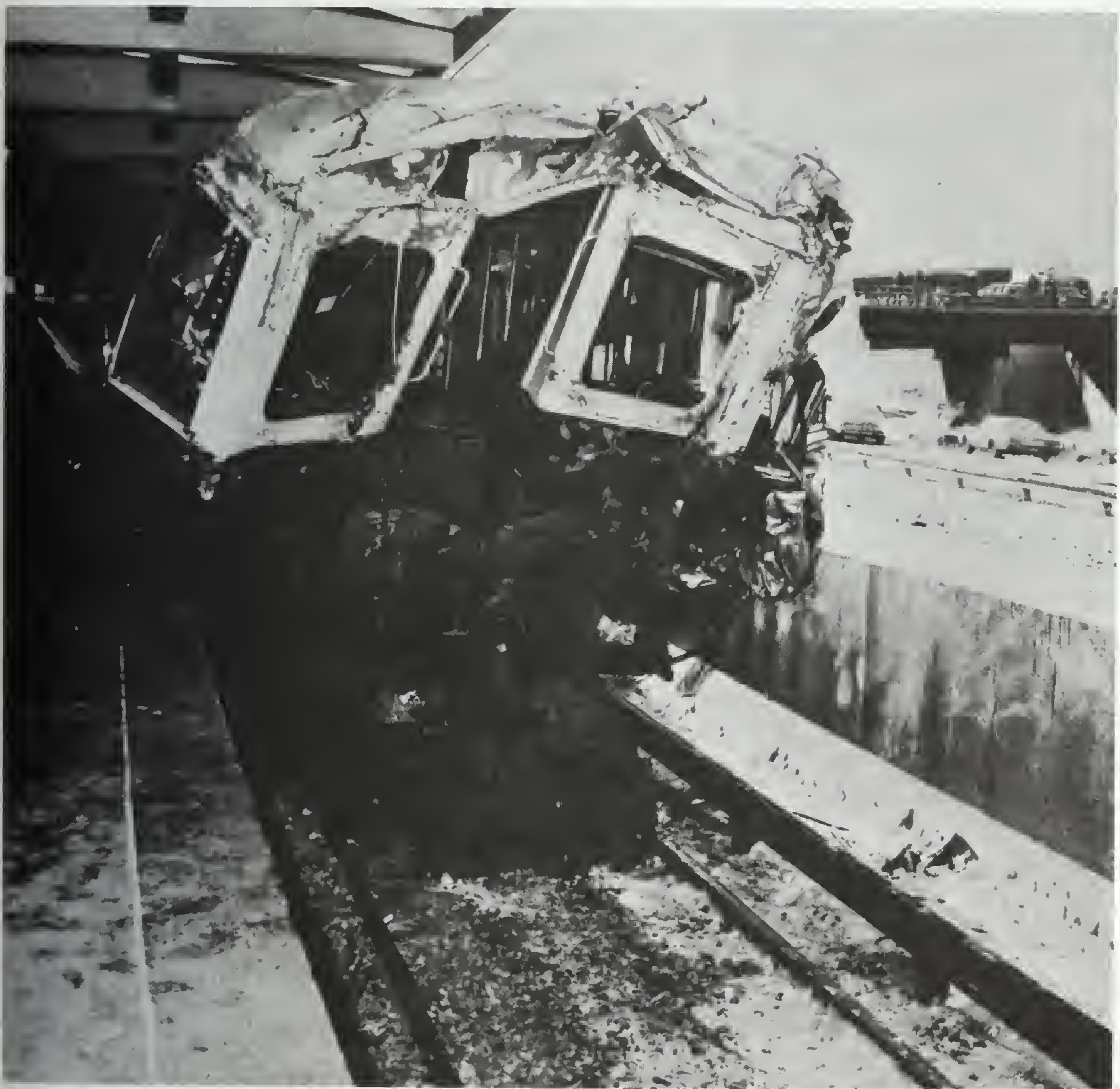

Figure 6. Train No. 104, Car 6583, after the impact.

The seats, the vertical hand bars, the door guards, and the modesty panels were the major injury-producing elements in the cars. Glass from the broken windows did not cause any serious injuries. The seats were attached securely to the floor and they cushioned the passengers. Passengers who were facing the impact point in each train were thrown forward and those who were facing away from the impact point were thrown backward. The faces of many of the seated passengers were injured when passengers struck the handrail across the top of the seatback. Standing passengers seemed to have sustained fewer injuries than those who were seated.

Based on a CTA survey of passengers on each train, 19.5 percent of the injuries occurred to the legs, 16.6 percent occurred to the neck, and 12 percent occurred to the head.

Tests and Research

Sight Distance Tests--After the accident, sight distance tests were conducted to determine the conspicuity of a train standing at the Addison Street Station. Some tests were conducted on a cloudy, overcast day, while others were conducted on a bright day. 3/ With the diminished light of an overcast day, a motorman can see a train in Addison Street Station as he departs Irving Park Station. As he descends the grade which approaches Addison Street Station, his ability to see a train in Addison Street Station is reduced because of the color of the 6000-series cars, which tend to blend with the station background, and by the overhead bridge for Hamlin Avenue, which blocks the view of the train for a short distance. Glare tends to reduce visual acuity at some points on a bright day.

Stopping Tests--Stopping distance tests were performed with a train similar in consist to train No. 315; however, the test train was empty. The point of brake application was chosen to be about 300 feet from where the rear of train No. 104 would have been on the day of the accident; this was the point at which the motorman of train No. 315 estimates that he saw train No. 104. The test results are tabulated in Table No. 1.

3/ Although time compensations were made to allow for the changed positions of the sun, the exact lighting condition on the day of the accident could not be duplicated.

Table No. 1

Test Run No.	Nominal Speed (mph)	Brake Mode *	Measured distance from application point (feet)
1	40	B-3 and Friction	346
2	40	B-4	239
3	35	B-4	171
4	30	B-4	171
5	25	B-3	104
5a	25	B-4	98
6	35	B-4	180

* The Friction brake is a drum brake; B-3 is a dynamic brake; B-4 is a combination of dynamic, friction, and track brakes (full capacity).

Based on these results, the stopping distance from 40 mph for a fully loaded, 2200-series car with the cineston control lever in the B-4 position was calculated to be 263 feet on level, tangent track. The stopping distances for 35 mph, 30 mph, and 25 mph were 200 feet, 147 feet, and 102 feet respectively. The deceleration rate for a fully loaded train with the cineston lever in the B-4 position was calculated to be 4.5 mph per second. These calculations allowed no reaction time for the motorman. Although the tests were made with an empty train, the curves and grade at Addison Street should compensate for some of the differences between the actual values and the calculated values. The tests indicate that 300 feet was adequate for the train to have stopped.

Equipment Tests--To determine the reason that the blue light and the circuit breaker actuated, the circuit breaker reset facilities on all cars which could be checked were examined and were found to be proper for correct operation. Investigators found that a bare cable on car No. 6583 had grounded the circuit on that car. In their depositions, CTA personnel indicated that the breaker should have reset each time the motorman operated the reset button, but that each time propulsion power was applied, the circuit breaker would trip again because of the grounded cable. Investigators determined that car No. 6584 had electrical flashing in two traction motors, some burning of resistance ribbons in the accelerator, flashing in the main controller between two contactors, and a carbonized area in the controller. These conditions could have caused the breakers to actuate. The train should have been operable if the motorman had opened the seven-point switch on car No. 6 (6583).

The train phone from train No. 104 received and transmitted properly when it was tested and no electronic components in the phone were broken. The brakes were found to be operating satisfactorily on the undamaged cars of train No. 315. The cab signals on train No. 315 were tested and were found to perform satisfactorily when the light bulbs were replaced. The train phone transmitted and received properly when it was tested.

Investigators determined that the light bulbs in the ADU of No. 2308 had burned out before the accident. At the time of the tests, the ATC was inoperative because of a blown fuse, which investigators believed had blown during the collision, and because of a faulty relay. Other than these two faults, the ATC functioned normally. The speedometer indicated properly, but it was not illuminated.

In addition to the carborne train phone equipment, the equipment in the controller's office and the system's wayside equipment were checked; the only defect found was a broken track bond wire at Irving Park. The broken bond wire would not have caused the communication system to malfunction. No reason why the system was not responsive on the morning of the accident could be found. However, the CTA operating personnel who use the train phone system stated that the signal pickup through the contact shoes from the third rail could introduce noise and make communications difficult.

ANALYSIS

The Collision

When the motorman of train No. 315 accepted permission to operate his train in the bypass mode, he followed the rule prescribed by manage- ment only in part. He should not have accepted permission from the yar foreman to bypass the ATC.

Once the motorman accepted the authority to bypass the ATC, his actions were governed by several factors which contributed to the collision. First, since operation of the train in the bypass mode required that the motorman use both hands and maintain an awkward position, he could not move once the train began to move. He could not adjust the sun visor or his cap, and if he had been required to answer a call on the train phone, he would have had to stop the train to do so. Second, he could have been distracted by the constant tone

which was being emitted in the cab because the ATC was malfunctioning. Third, he was blinded by the sun as his train approached Addison Street Station, and he could not adjust his sun visor or change his position to lessen the effect of the sun's glare. Fourth, he knew that his train would not have to stop at Addison Street Station and he expected that No. 104 already would have left the station. Fifth, his understanding of the correct operating speed was incorrect; he was operating his train at 35 mph in accordance with the visual rule, but Rule 178B required him to operate the train at 25 mph because of the reduced visibility caused by the sun's glare.

The two curves in the approach to Addison Street Station caused the station to be viewed at an offset by the approaching motorman. Also, because of the descending grade, the overhead bridge and the bridge piers momentarily obstructed his visibility. However, the shadow of the bridge, about 1,700 feet from the station, afforded him a respite from the sun's glare and he could have seen No. 104 at that time. When he finally saw the standing train, he estimated that he was 300 feet from the other train. Since the tests showed that 300 feet were adequate, at 35 mph, to have stopped the train short of collision, either No. 315 was moving faster than the speed estimated by the motorman or it was closer to the standing train than the motorman realized.

The anticlimber on the lead car of No. 315 struck the anticlimber on the rear car of No. 104 slightly off center because of the curvature in the track. Since the anticlimbers prevented the cars from overriding, the trains were forced upward and eastward until the cars' travel was restricted by the concrete platform. This eastward movement is supported by the fact that passengers struck and broke several windows on the west side of the trains. At some point during impact, one or both the trains created a path for the power to short circuit between the third rail and the running rail. The power supervisor's log indicated that the short circuit was removed when both trains stopped, because power was restored after 8 seconds. This quick, automatic restoration of power created a potentially hazardous situation. The Safety Board noted the hazards of a quick, automatic restoration of power in two other accident reports. 4/ Confused passengers might have

4/ "Automobile Intrusion onto the Long Island Railroad Electrified Tracks and Fire, Garden City, N.Y., August 8, 1973." NTSB-HAR-74-3.

"Penn Central Company, Electrocution of Juvenile Trespasser on Penn Central Tracks, Washington, D.C., May 14, 1971." NTSB-RAR-72-3.

wandered onto the tracks and contacted the third rail, or the activities of rescue personnel might have caused them inadvertently to have contacted the third rail.

ATC Bypass Procedures

Although only the controller had the authority to grant a motorman permission to operate a train in the bypass mode, it had become accepte that this authority also belonged to the rail service supervisor. The delegation of authority is sometimes propagated beyond its intent, as ca be seen in this instance, where the rail service supervisor used the yar foreman to authorize the motorman of train No. 315 to bypass the ATC. The motorman accepted this permission without question although he did not receive the authorization from the rail service supervisor.

The motorman did not exchange the required information with the supervisor, and the supervisor did not notify the controller, so the controller did not know that train No. 315 was operating without the ATC. Even if he had, there were no established procedures by which the controller would notify trains ahead that a train was operating without the ATC. Also, the controller did not know that train No. 315 had tried to contact him from Jefferson Park at the beginning of his run and that there might be trouble with his train phone. If the rail service supervisor was aware of the problem with the train phone, he did not advise anyone of the difficulty.

The rail service supervisor had several options on the morning of January 9, 1976. He decided to allow the train to run with the ATC inoperative. There were several factors that caused him to reach this decision; one of these was his personal knowledge of the motorman's performance record. Operating rules should be equally applicable to all those responsible to them. A system cannot justify the operational practice of the application or abandonment of rules based on an individual's performance or knowledge.

The logic that requires a motorman to hold the bypass button depressed at all times is valid; it assures that the motorman is aware that he is operating the train with the ATC inoperative. However, there is much to be said for another system in use on the CTA, which allows the motorman to set the bypass button. Once the button is depressed, it will remain in operation without his holding it. Although CTA operating rules no longer permit a train to depart a terminal with the ATC inoperative, there are still times when it will be necessary to move a train over the main track with the bypass button in use.

A motorman's being required to operate a train without having the freedom to move either hand is not the best situation, and since there is an alternative, the alternative should be studied to determine if it should be used on all trains.

Since the ATC was inoperable and the ADU was not illuminated, the motorman received no cab signal indications and he had no effective speed control. The operation and control of the train was totally dependent on his understanding of the rules and his visual perception and reaction.

The CTA management, by promulgating instructions which allowed a train to be operated without the ATC operable, disregarded their years of operational experience which indicated that the human operator needed a safety check, and they undermined the technology that provided that check. The safety of the system was vested in one person; when the motorman of train No. 315 failed, the system had no backup without the ATC.

Maintenance

The maintenance program which is followed by the CTA for the ATC equipment does not seem to cover adequately the minor elements of the equipment. The inspection for ATC troubles and for light bulbs in the ADU is not done as aggressively nor as systematically as it should be, based on their failure records. Burnt-out light bulbs or broken seals should be detected before a train departs its terminal. A more frequent inspection in some of these minor problem areas to eliminate some of the simple failures between the extensive 6,000-mile checks might reduce en route failures. This probably will be accomplished by the predeparture tests which CTA is planning to implement.

A failure rate of 6.5 per day for the ATC system indicates that the system components should be reviewed with the equipment manufacturers to determine if problems in design, installation, or maintenance exist. If cab signals and ATC continue to be installed on the CTA system, the failure rate of 6.5 per day undoubtedly will increase as the number of trains increases and as the miles of track operated by ATC and cab signals increase.

Communication System

The motormen of trains No. 315, No. 104, and No. 106 attempted several times to communicate with the controller by their train phones, but none of the calls were acknowledged. The motorman of No. 315 heard communications when he attempted to call the controller from Jefferson Park; this indicates that his receiver was operable; however, no one indicated that they heard his transmission. The motorman on train No. 106 intercepted the call from train No. 104 and talked with that motorman. This indicates that the phones on No. 106 and No. 104 were functioning properly. It may be that the transmitted signal from trains Nos. 104 and 106 were too weak and that the controller could not hear it, but it also may be that the controller was away from his operating position at that time. If a controller is away from his operating position, arrangements should be made to cover his responsibilities.

The inability to establish communications may have affected the outcome of the accident. If the motorman of train No. 104 had completed his call to the controller, the controller could have notified train No. 315 of the delay, or train No. 315 might have monitored the call and thus have been alerted. This situation indicates a need to establish more dependable communication and to have more assurance that communication equipment is operable when a train leaves a terminal. A predeparture test for the train phone should accomplish this.

There must be some assurance that a train between terminals can contact the controller or, if necessary, a nearby train. Also, the controller's ability to communicate with a train may mean the difference between no accident or a catastrophe. The Safety Board has investigated several accidents in which the communication system failed either to prevent or to decrease the severity of the accident because of its inadequacy or because of faulty equipment. 5/ Since the contact between the third rail and the pickup shoe may be at fault, it should be studied. It may be that varying metallurgical compositions, such as hardspots, may influence the sensitivity of the pickup device.

5/ "Penn Central Transportation Company Train Collisions, Leetonia, Ohio, June 6, 1975." RAR-76-2.

"Head-on Collision of two Burlington Northern Freight Trains, Near Maquon, Illinois, May 24, 1972." RAR-73-4.

Training Program

The CTA training program for the various operating positions appears to provide an indepth coverage for the elements of those positions. However, there seems to be a lack of comprehension and understanding by operating personnel with respect to certain rules. This is not a new situation, nor is it peculiar to the CTA. The Safety Board has encountered this same problem on several occasions, and the problem demonstrates a need to improve instruction and review techniques. For example, all of the motormen and some of the supervisors and management personnel interviewed did not know the maximum authorized speed for operating in the by-pass mode. If the employees do not know this speed--something which they use almost daily--it indicates that there may be other vitally important rules which they do not fully understand.

The training program provides an employee with classroom instruction and on-the-job training until he is qualified for a particular job, but it does not insure that he is kept up to date on rules and operating procedures. Although instructors and supervisors monitor the performance of operating employees for their observance of rules, this does not insure that an employee is knowledgeable of the operating rules. The possibility that employees are not up to date on rules and procedures is amplified because of the "extra board" arrangement which is used by the CTA and other railroad companies. A regularly assigned conductor may be a qualified motorman, but if he does not have enough seniority to hold a regular job as a motorman, he operates regularly as a conductor and infrequently as a motorman. He may become deficient in those rules that specifically apply to a motorman's duties.

The testimony of some employees after the accident indicates that they did not understand fully the scope of their responsibilities. The conductor of train No. 315 believed that the motorman should have told him he was operating without the ATC. However, the motorman did not report it and he did not know whether he was required to report it. It would seem that the entire crew should know the condition of the equipment. One conductor who testified believed that he had no responsibility to monitor the performance of his motorman. However, the rules state that the conductor and the motorman are jointly responsible for the safe operation of their train. Apparently, since the position of motorman is rated a promotion from that of

conductor, it is accepted that the motorman has more authority than the conductor. In reality, both men need to be aware of the conditions under which they are operating.

Enforcement of Operating Rules

Employees are responsible for observing a number of rules that are in effect, according to the rulebook, but that are not enforced by the management. For example, the rule that requires flag protection for trains is in effect, yet management does not deem it necessary nor safe for the men to flag. If such is the case, the rule should be annulled.

Both operating employees and supervisory employees seemed confused on the application of some rules. Certainly instructors or supervisors cannot instruct on a rule that they themselves are not sure of. The fact that management elects to have in effect some rules which they fail to enforce can only lead to confusion and a disregard of the rules by the employees. If employees are not chastised for violating one rule, then it is reasonable to believe that they may violate others. The Safety Board addressed the necessity of being consistent in the enforcement and the application of operating rules in a special study. [6/] Rules that have outlived their purpose or usefulness should be annulled or superseded, and those for which employees are responsible should be enforced consistently.

Regulation of the CTA

In the past, the operations of the CTA have not been subject to any regulatory authority. While it is possible to provide safe and reliable transportation without regulation, it is difficult for those within the structure of a company to maintain objectivity with respect to company problems. Since regulatory agencies view a system from the outside, they may provide better insight into safety and operating problems. Also, guidelines should be established by an external authority because the economics of internal policies may allow requirements for maintenance, installation standards, design, etc., to be relaxed. Unbiased controls by a regulatory agency may insure that a company's operations are safer and more dependable.

6/ "Signals and Operating Rules as Causal Factors in Train Accidents." NTSB-RSS-71-3.

The CTA's new safety department has developed to the point where it can begin to be effective. However, it cannot reach its full potential if the CTA management restricts it to an advisory role. It needs to become involved in all facets of the CTA operations.

CONCLUSIONS

1. The motorman of train No. 104 attempted to contact central control to report the activated circuit breaker on his train, but he did not provide for flag protection; these actions were in accordance with his understanding and practice of the operating rules.

2. The rail service supervisor authorized the motorman of train No. 315 to operate his train in the bypass mode.

3. The rail service supervisor authorized the operation of train No. 315 without the ATC because it was an approved procedure and because he was influenced by such factors as equipment shortage, track blockage, late schedules, a desire to provide service, and a personal knowledge of the motorman's performance record.

4. The procedure prescribed by the rules to authorize the operation of a train without the ATC was not followed.

5. When the ATC is bypassed, the speed control function is nullified and the conductor's and motorman's emergency brake controls are inoperative.

6. Either train No. 315 was moving faster than the speed estimated by the motorman or he failed to see the standing train until he was closer to it than he realized, and his train consequently collided with No. 104.

7. The train phone system did not operate reliably and it failed to provide the necessary communications with the controller on the morning of the accident.

8. The cars absorbed the crash energy in accordance with their design intent.

9. The CTA training program does not insure that operating employees remain familiar with the operating rules which apply to each position for which they are qualified.

10. The CTA maintenance program is inadequate to assure that equipment is functioning properly.

11. The CTA rulebook needs to be updated to reflect current job responsibilities and operating conditions.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the motorman of train No. 315 to perceive standing train No. 104 at a sufficient distance to permit him to stop his train before striking No. 104. Contributing to the collision were the rule that permitted the operation of the train with the automatic train control and the cab signals inoperative, the lack of consistent enforcement of operating rules, the absence of flag protection against following trains, the failure of the train phone system to provide reliable communications, and the violation of the 25-mph speed limit required by Rule 178B.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board submitted the following recommendations to the Chicago Transit Authority:

> "Study the procedure which it implemented on January 10, 1976, to handle trains which have inoperative automatic train controls (ATC) or cab signals to insure that all hazards have been considered and their potential has been minimized. (R-76-35) (Class II, Priority Followup)
>
> "Implement predeparture tests at terminals to insure that the ATC, the cab signals, and the train phones are operating properly. (R-76-36) (Class II, Priority Followup)
>
> "Review the maintenance schedule and procedures for the ATC and the cab signals to determine their adequacy to: a) Detect the failure of nonvital functions or components

and b) detect and isolate substandard or progressively deteriorating components which result in failure, so that these can be dealt with and so that the inservice failure rate can be reduced. (R-76-37) (Class II, Priority Followup)

"Insure that the train phone system provides dependable, reliable, and backup communication for operational control and that proper procedures are in effect to provide emergency warnings and instructions. (R-76-38) (Class II, Priority Followup)

"Update the book of operating rules so that current supervisory titles and functions are in agreement, and upgrade it so that only those rules for which employees are responsible and that are enforceable and necessary for safe operation are contained therein. (R-76-39) (Class II, Priority Followup)

"Reassess the operating employees' training program and the method which is used currently to evaluate their understanding and knowledge of rules and operating procedures to insure that both are effective. (R-76-40) (Class II, Priority Followup)

"Develop the full potential of the Safety Department, involve it in all phases of the system operation including operations, design, maintenance and training, and provide it with more than advisory authority so that it can require implementation of system safety programs. (R-76-41) (Class II, Priority Followup)"

The Safety Board also submitted the following recommendations to major operational rapid transit organizations.

"Prohibit trains with inoperative automatic train control or cab signals from departing a terminal for main track operation. (R-76-42) (Class I, Urgent Followup)

"Develop a procedure to discharge passengers and remove trains from service immediately if they develop automatic train control problems or cab signal problems while en route. (R-76-43) (Class II, Priority Followup)

> "Insure that communication facilities are adequate for dependable operational control and that proper procedures are in effect to provide emergency warnings and instructions. (R-76-44) (Class II, Priority Followup)"

The Safety Board also submitted the following recommendation to the Governor, State of Illinois:

> "Insure that the Regional Transit Authority exercises its statutory regulatory authority over the Chicago Transit Authority, so that the Chicago Transit Authority may provide the safest practical transit service. (R-76-45) (Class II, Priority Followup)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

July 8, 1976

APPENDIX A

Traincrew Information

The motorman of train No. 315 was hired by the CTA on January 2, 1970. He was qualified as a conductor on January 15, 1970, as a flagman on February 13, 1970, as a motorman on January 22, 1971, and as a switchman on July 2, 1971. He had been selected by management to begin supervisor training on January 12, 1976.

The motorman of train No. 315 submitted to an alcohol and drug test on the day of the accident. Both tests were negative. The motorman's eyes were examined shortly after the accident and no handicaps or defects were detected.

The conductor of train No. 315 was hired on October 25, 1974. He was qualified as a conductor on October 31, 1974, as a flagman on April 21, 1975, as a motorman on April 13, 1975, and as a switchman on July 25, 1975.

APPENDIX B

Excerpts from "An act providing for establishment of a REGIONAL TRANSPORTATION AUTHORITY as amended"

December 31, 1974

Section 2.11 Safety.

The Authority may establish, enforce and facilitate achievement and maintenance of standards of safety against accidents with respect to public transportation provided by the Authority or by transportation agencies pursuant to purchase of service agreements with the Authority The provisions of general or special orders, rules or regulations issue by the Illinois Commerce Commission pursuant to Section 57 of "An Ac concerning public utilities", approved June 29, 1921, as amended, whic pertain to public transportation and public transportation facilities or railroads will continue to apply until the Authority determines that different standards are necessary to protect such health and safety.

APPENDIX C

CTA Service Bulletin changing procedures for handling inoperative ATC and Cab Signals

TO: All Concerned, Rail

SUBJECT: CAB Control Signal

EFFECTIVE: Saturday, January 10, 1976

No train on cab-signaled routes of the system will be allowed to go into passenger service from a starting terminal if the cab signal equipment of the head car of the train is not fully operational.

Should the cab signal equipment on a train in passenger service on a cab-signaled route become less than fully operational, the passengers will be taken off the train at the next scheduled station.

In addition, for a train developing such difficulty while in passenger service, supervisory personnel will be dispatched immediately to intercept and to take charge of the train and to remove the train from the route.

Manager, Transportation

APPROVED:

General Operations Manager

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

HEAD-ON COLLISION OF TWO PENN CENTRAL TRANSPORTATION COMPANY FREIGHT TRAINS

NEAR PETTISVILLE, OHIO

FEBRUARY 4, 1976

REPORT NUMBER: NTSB-RAR-76-10

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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4. Title and Subtitle Railroad Accident Report -- Head-on Collision of Two Penn Central Transportation Company Freight Trains, Near Pettisville, Ohio, on February 4, 1976		5. Report Date September 10, 1976
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Surface Transportation Safety Washington, D. C. 20594		10. Work Unit No. 1795-A
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		13. Type of Report and Period Covered Railroad Accident Report February 4, 1976
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

About 11:52 p.m. on February 4, 1976, Penn Central freight train NY-12 collided head-on with freight train BM-7 near Pettisville, Ohio. The 3 locomotive units and 21 cars of train NY-12, and the 4 locomotive units and 4 cars of train BM-7 were derailed. One locomotive unit of each train was destroyed and the derailed cars were heavily damaged. The two crewmembers in the lead locomotive of both trains were killed and one crewmember on each train was injured as a result of the collision. The estimated cost of damages was $1,165,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer to stop train NY-12 west of signal 3272E as required by signal indication, and the inability of the crew in the caboose of train NY-12 to take preventive action.

As a result of its investigation, the Safety Board submitted three recommendations to the Federal Railroad Administration.

17. Key Words Railroad accident; head-on collision; freight trains; traffic control signal system; train control system; violated signal; switch point detection system; human failure.		18. Distribution Statement This document is available through the National Technical Information Service, Springfield, Virginia 22151.	
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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: September 10, 1976

HEAD-ON COLLISION OF TWO PENN CENTRAL TRANSPORTATION COMPANY FREIGHT TRAINS NEAR PETTISVILLE, OHIO FEBRUARY 4, 1976

SYNOPSIS

About 11:52 p.m. on February 4, 1976, Penn Central Transportation Company freight train NY-12 collided head-on with freight train BM-7 near Pettisville, Ohio. The 3 locomotive units and 21 cars of train NY-12, and the 4 locomotive units and 4 cars of train BM-7 were derailed. One locomotive unit of each train was destroyed and the derailed cars were heavily damaged. The two crewmembers in the lead locomotive of both trains were killed and one crewmember on each train was injured as a result of the collision. The estimated cost of damages was $1,165,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer to stop train NY-12 west of signal 3272E as required by signal indication, and the inability of the crew in the caboose of train NY-12 to take preventive action.

FACTS

The Accident

About 9:15 p.m. on February 4, 1976, Penn Central Transportation Company's (Penn Central) 1/ freight train NY-12 departed Elkhart, Indiana, eastbound for Toledo, Ohio. The train consisted of 3 locomotive units and 73 cars. It had been given a mechanical inspection and an initial air brake test that disclosed no defective conditions before its departure. Crewmembers twice used the train radios during the air brake test.

Train NY-12 passed several westbound trains and was crossed over between track 1 and track 2 twice during the trip between Elkhart and the collision point. The train passed through several slow-order locations, which required that it vary its speed from 40 to 30 mph. The engineer last applied the automatic air brake at Bryan, about 16 miles west of the collision point, where the train was stretched to prevent a train separation. There were no radio transmissions between the crewmembers

1/ Penn Central became part of the Consolidated Rail Corporation in April 1976.

on the caboose and those on the locomotive. The conductor, who was riding on the caboose, stated that he noted no descrepancies in the train's operation between Elkhart and the collision point.

When NY-12 was near Stryker, about 4 miles west of control point (CP) 329, it was seen by the locomotive crewmembers of a westbound train on track 1. The crewmembers noticed that the headlight of NY-12 was on dim; they watched the headlight for about 4 miles until the trains passed at CP 329 and they stated that the headlight never changed to bright.

Penn Central freight train BM-7 originated in Selkirk, New York, and was last serviced before the accident at Cleveland, Ohio. The train consisted of 4 locomotive units and 113 cars when it departed Cleveland. Mechanical inspections and air brake tests disclosed no defective conditions. BM-7 stopped on the main track at Toledo to change crewmembers, after which it departed westward on track 2 for Elkhart at 10:30 p.m. on February 4, 1976. The conductor and flagman inspected the train and checked the radio by calling the engineer as the train departed. The engineer turned the train's headlight on bright in accordance with Operating Rule No. 17.

About 11:43 p.m., BM-7 was moving west on track 2 in the vicinity of CP 320 and NY-12 was moving east on track 2 in the vicinity of CP 329 near Archbold. The train dispatcher planned to have train BM-7 cross over from track 2 to track 1 at CP 327 so that NY-12 could proceed east on track 2. (See figure 1.)

When BM-7 entered the block between CP 320 and CP 327, it caused signal 3272E, which was governing the eastbound movement of NY-12, to display a "stop" aspect. As BM-7 moved toward CP 327, the switches were lined and the signals actuated for BM-7 to cross over to track 1. When train NY-12 reached signal 3272E, it should have stopped in accordance with the signal indication until BM-7 had crossed over. However, it passed the signal about 35 mph and continued east without reducing its speed. In fact, the train's speed did not change appreciably between Bryan and the collision point.

When the engineer of BM-7 saw NY-12 approaching on the same track, he called over the radio, "Archbold eastbound--stop your train," but he received no response from NY-12. The two trains collided about 11:52 p.m., 1 mile east of CP 327. The collision ruptured the fuel tanks of several locomotive units and the escaping fuel ignited and exploded. The two crewmembers on the lead locomotive of each train were killed and two others were injured.

Damages

The 3 locomotive units and 21 cars of NY-12 and the 4 locomotive units and 4 cars of BM-7 were derailed. The lead locomotive units from each train were destroyed and the derailed cars were heavily damaged.

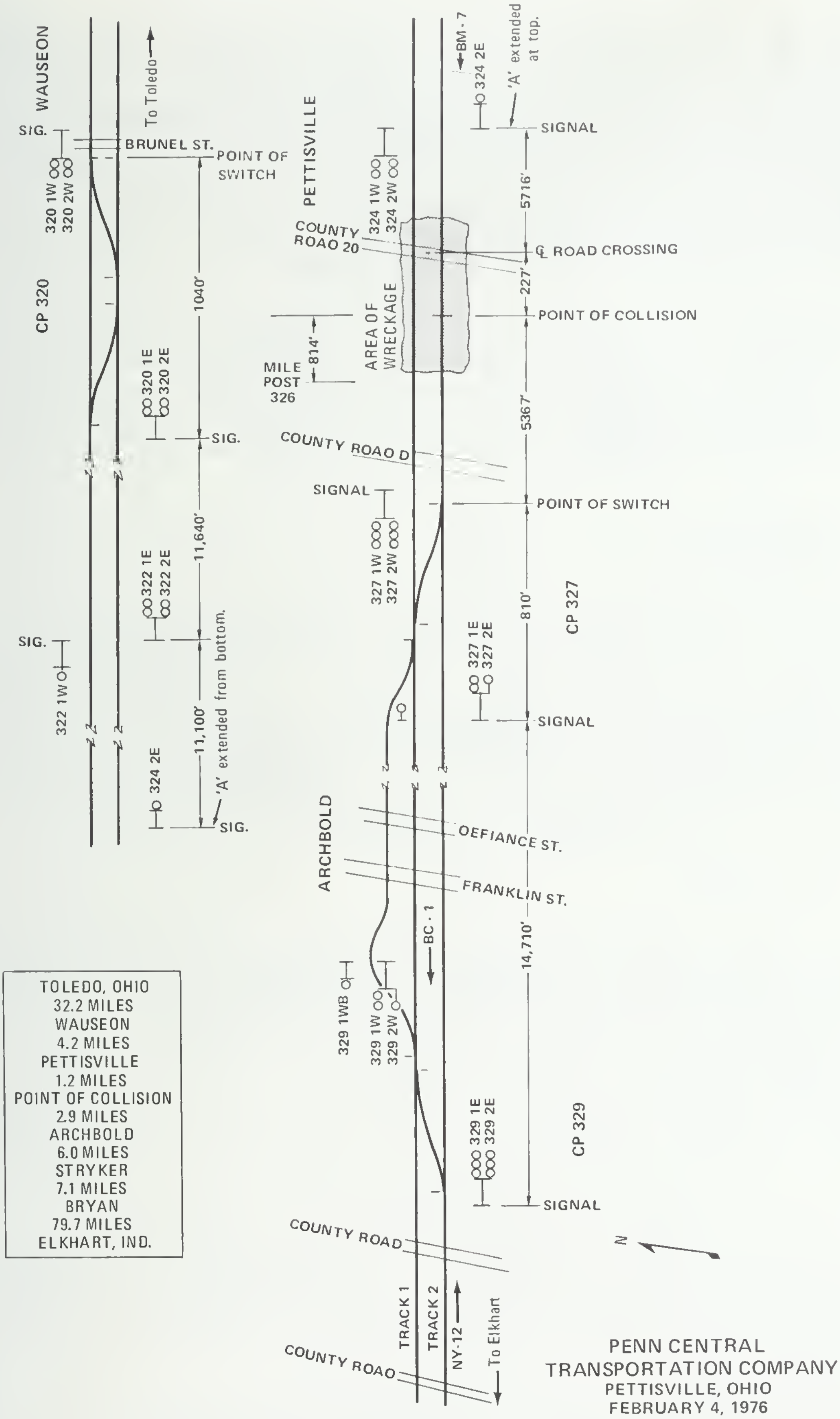

Figure 1. Track layouts at and near accident site.

About 400 feet of track 2 and 100 feet of track 1 were damaged. The switch of the crossover at CP 327 was damaged when train NY-12 ran through the switch after it was lined for the crossover movement. The operating rod was bent; this caused the far switch point 2/ to gap open about three-fourths of an inch. A portion of the head of the near switch point, opposite the point that had gapped open, was broken.

Cost of damages was estimated as follows:

Locomotives	$928,041
Cars	64,600
Lading	36,000
Track and Signal	50,052
Removal of wreck	86,086
Total	$1,164,779

The Accident Site

The double main track is straight for more than 15 miles both east and west of the point of collision. A No. 20 crossover for westbound trains connects track 2 to track 1 at CP327. The grade for westbound trains averages 0.17 percent descending as they approach the accident point. There were five rail-highway grade crossings in the 5-mile area west of the accident site for which NY-12's headlights should have been on bright. It was dark when the trains collided; the weather was cloudy, visibility was about 15 miles, and the temperature was 22°F.

Method of Operation

Trains are controlled in both directions between Toledo and Elkhart on the double-track line by signals of an automatic traffic control system. Interlocked crossovers, called control points, are provided at various locations to facilitate the handling of traffic on the main tracks. Crossovers and controlled signals are operated by the dispatcher, who is located in Toledo, Ohio. The dispatcher can radio train orders to traincrews; all radio communications for train operation are recorded.

The maximum authorized speed for freight trains is 50 mph. Limited and medium speeds cannot exceed 45 and 30 mph, respectively.

Penn Central Operating Rule No. 17 requires that the headlights on the front of every train be displayed brightly by day and by night. They must be dimmed when a train is approaching from the opposite direction.

2/ At CP 327 when the switch is lined for a crossover movement, the switch point, which is open, is called the near point and the opposite switch point, which is closed, is called the far point.

Signal System

The train dispatcher can cause the controlled signals to display a stop- or a proceed-type aspect. Once the dispatcher or the track occupancy causes the controlled signals at CP 327 and CP 329 to display a stop aspect, they will not display a proceed aspect until the dispatcher activates the circuit. Other intermediate signals function as automatic-block signals. The signals are approach lighted. (See figure 1.)

When a westbound train which is being operated on track 2 in the block between CP 320 and CP 327 is to be crossed over to track 1 at CP 327, and when the block between CP 327 and CP 329 on track 1 is unoccupied and signal 3291W displays an aspect other than "stop," the signals will display the following aspects to an approaching train:

Signal Number	Aspect	Name	Indication
3242W	green-over-red-over-red	Clear	Proceed
3272W	red-over-flashing green-over-red	Limited Clear	Proceed: Limited speed within inter-locking limits
3271W	red-over-red-over-red	Stop	Stop
3241W	yellow-over-red-over-red	Approach	Proceed prepared to stop at next signal. Train exceeding medium speed must at once reduce to that speed.
3272E	red	Stop	Stop
3292E	yellow-over-red-over-red	Approach	Proceed prepared to stop at next signal. Train exceeding medium speed must at once reduce to that speed.

If signal 3291W displays a "stop" aspect and the block between CP 327 and CP 329 on track 1 is unoccupied, then the following signal aspects will be changed and all other signals will remain unchanged:

Signal Number	Aspect	Name	Indication
3272W	red-over-flashing yellow-over-red	Limited Approach	Proceed at limited speed preparing to stop at next signal.

If the block on track 1 is occupied between CP 327 and 329, then the following signals will display the aspects shown below and all other signals will remain unchanged:

3272W	red-over-red-over-red	Stop	Stop
3242W	yellow-over red	Approach	Proceed prepared to stop at next signal. Train exceeding medium speed must at once reduce to that speed.

The signal system is properly protected for time, route, and traffic direction.

A train graph in the dispatcher's office automatically records entering and leaving times at all control points. In addition, a control board has panel indication lights that show whether signals are displaying stop- or proceed-type aspects, whether a block is occupied, and whether a switch is lined for a straight or a crossover movement.

Each controlled switch is provided with a device which should detect a switch point that does not fit properly against the running rail. The device is designed to cause the signal which governs movements over the switch to display its most restrictive aspect when the switch points are gapped open more than one-fourth inch. A detector rod connects the device to one of the two switch points. At CP 327, the switch point to which the detector rod is connected is the near point. Switch protection is required by 49 CFR 326.205.

Train Equipment

The diesel-electric locomotive units of NY-12 and BM-7 were provided with air-actuated deadman safety controls, speedometers, and radios with which the crewmembers on the locomotive could converse with those on the

caboose, with other trains, and with the train dispatcher. The crewmembers on the caboose of each train were provided with portable radios. The locomotives were not equipped with speed-recording equipment.

Crewmembers of NY-12

The engineer was 60 years old and his last physical examination, in February 1975, disclosed no defective physical condition. He had been operating locomotives for 25 years.

The front brakeman was 41 years old and was required to have a physical examination each 6 months because of a heart condition. His last examination, in September 1975, indicated that he was fit for duty.

An investigation of the activities of the crewmembers during the 24-hour period preceding the accident did not disclose any condition which would have contributed to the accident. The engineer and brakeman had been off duty for 12 1/2 hours when they reported for this assignment. It was not possible to determine their physical condition, but other crewmembers reported that they appeared to be well rested and fit for duty.

It was not possible to determine whether the engineer or the front brakeman were incapacitated immediately before the accident nor was it possible to obtain alcohol or drug tests because of the crushing damage of their bodies and the complete loss of blood.

Tests

Tests by the carrier were observed by representatives of the FRA. Tests on the braking system of the undamaged cars and on the air brake components of the locomotive units were performed. The tests disclosed that the train braking systems of both trains were functioning properly before the accident.

Signal 3272W was observed following the accident to display a "limited approach" aspect when the crossover at CP 327 was lined for the crossover movement, even though the switch point was gapped open about three-fourths of an inch. Signal 3291W displayed a "stop" aspect after the train on track 1 had cleared the block but it could not be placed in proceed position by the train dispatcher because all of the control wires had been torn out by the derailment.

Tests also were performed on the signal system under the observation of an FRA representative. The tests disclosed that the signals were functioning as intended before the accident.

ANALYSIS

Accident

When BM-7 occupied CP 320 about 11:42 p.m., signal 3272E and 3292E, when lighted, displayed "stop" and "approach" aspects, respectively. At this time, NY-12 was west of signal 3292E and should have received the indication that it was required to stop short of signal 3272E. Nothing happened from the time BM-7 entered CP 320 until the accident occurred to change the "stop" aspect which was displayed by signal 3272E.

The crewmembers on the train which was westbound on track 1 watched NY-12 for about 4 miles and stated that the headlight of NY-12 never changed to bright, although the rules of the carrier require the headlights to be on bright except when a train is closely approaching or passing another train. Since there were no other trains between NY-12 and the westbound train on track 1, the engineer of NY-12 should have had the headlight on bright until his train was near the westbound train.

The last brake application of NY-12 was made near Bryan. Shortly after NY-12 passed signal 3292E, it entered a speed restriction zone where the speed was required to be reduced to 30 mph. The engineer apparently made no attempt to reduce the speed of the train as it continued eastward at 35 mph.

There was no reported radio communication between the crewmembers on the locomotive of NY-12 and anyone else after the train departed from Elkhart, and they did not answer the call which the engineer of BM-7 made just before the trains collided. Since the radio was operable when the train departed Elkhart, the lack of radio communications apparently was not caused by faulty equipment. However, the damaged condition of the radio prevented determination of its operable status after the accident.

These factors indicate that the engineer and the front brakeman were not responsive while train NY-12 passed the stop signal at CP 327, ran through the switch, and continued east to collide with BM-7. It is also questionable whether the crewmembers were responsive while the train traversed the 16 miles between Bryan and the collision point. The reason for their lack of response could not be determined.

Operating Rules

At present, the Penn Central has no rule or procedure which requires that the activities of crewmembers on a locomotive be monitored by employees of passing trains or by employees along the track. In order to determine that engine crews are not incapacitated in the course of their duty, such a rule should be established. The rule should require locomotive crewmembers to acknowledge crewmembers of passing trains and to acknowledge employees along the track. If such acknowledgement is not received, employees should be required to notify the other train's

conductor, the dispatcher, or both. The conductor should be required to determine why the crewmembers on the locomotive failed to respond, and if he does not receive a satisfactory response, he should stop the train.

Had such a rule been in effect at the time of the accident, the engine crew of the westbound train on track 1 would have alerted the conductor of train NY-12. If the conductor of train NY-12 did not receive a proper acknowledgement from the engineer, he would have been able to stop the train short of CP 327.

Safety Controls on Locomotives

The locomotive units of NY-12 were provided with an air-actuated safety control device which required a floor pedal to be depressed while the unit was operating. Release of the pedal results in the actuation of a warning whistle and, if the engineer does not take corrective action within a specified time, the brakes of the train are applied. This device can be nullified by placing a weight on the pedal or by wedging the pedal into a depressed position with a bar or stick. Even if the engineer had become incapacitated or had fallen asleep, the position or weight of his body could have kept the pedal in the depressed position. Because of the extensive damage to the cab of NY-12's locomotive, it could not be determined if the safety control device had been made inoperative.

Responsibilities of Other Crewmembers

The front brakeman has no device in the locomotive cab to insure that he is alert. His major duty is to observe the engineer; the movement of the train is not dependent on his actions. Most of the time, the front brakeman is junior to the engineer both in age and experience and is always junior in position. It is not unusual for a front brakeman to be reluctant to take over the operation of the train or even criticize the engineer except as a last resort.

If the front brakeman were assigned radio duties, then each communication with the locomotive would check his alertness and would keep him in contact with the conductor for instructions.

The conductor is generally considered to be in charge of the train and he shares with the engineer responsibility for the train's safety. When the conductor is in the caboose of a long freight train, many times he is unable to observe the aspects displayed by signals before the locomotive passes them; he has no device in the caboose to indicate the speed of the train but must rely on his judgment; and he cannot monitor the engineer and the front brakeman. Since the conductor shares the responsibility for the safety of the train, he should be provided with sufficient information to carry out these duties.

Signal System

The signal system on this section of main track incorporates signal circuits and concepts used throughout the railroad industry. If the engineer of NY-12 had operated his train in compliance with the signal indications, he would have stopped the train west of signal 3272E. The continuance of train NY-12 through CP 327 indicates that the engineer and front brakeman either misinterpreted signal 3272E or failed to see it.

Although the signals were operating properly, the system as presently designed does not provide any safeguards to prevent trains from passing the stop signals. At one time, this area was equipped with an automatic train stop feature. This feature, however, was eliminated when train speeds were reduced below 80 mph. Consequently, the signal system now depends upon the employees' compliance with operating rules. Because of the double-track, bidirectional method of operation in this territory, a train control system could be used effectively to provide compliance with operating rules. The lowering of train speeds to under 80 mph did not justify the elimination of the signal backup system.

The examination of the damage to the switch on track 2 at CP 327 disclosed that as the locomotive of NY-12 ran through the switch, which was lined for the crossover movement, the wheel sprung the closed far switch point and bent the operating rod. This permitted the far switch point to gap open. The wheels on the opposite side of the locomotive broke the head of the near switch point and went behind the point and onto the stock rail. This prevented the near switch point and the detector rod from moving toward the stock rail and actuating the detector device. Because of this, signal 3272W, which governed movements over the switch, was able to display a proceed aspect despite the defective switch resulting from the accident. This type of protection does not comply with the requirements of 49 CFR 236.205.

CONCLUSIONS

1. The double main track was lined for westbound BM-7 to cross over to track 1 at CP 327 so that NY-12 could continue east on track 2.

2. NY-12 passed signal 3272E, which displayed a "stop" aspect, and continued east without stopping for about 1 mile, where it collided with BM-7.

3. There was no known activity of the locomotive crewmembers on NY-12 between Bryan and the collision point. The reason for their lack of activity could not be determined.

4. The conductor and flagman on NY-12 were not aware that the train was being operated in violation of signal 3272E and that the engineer and front brakeman were not responsive. Since the conductor was at the back of the train, he could not monitor the activities of the crewmembers on the lead unit except by radio. He also was not required to do so.

5. The front brakeman is not assigned sufficient duties which would insure that he remains alert.

6. If the Penn Central required the locomotive crewmembers of trains to acknowledge or signal the crewmembers of passing trains and to report any signals which are not acknowledged, the accident might have been avoided.

7. The arrangement of the detector device on the switch at CP 327 on track 2 did not comply with 49 CFR 236.205 because it permitted a proceed aspect to be displayed even though the switch point was gapped open.

8. If the signal system still had been provided with an automatic train stop system, the accident might have been prevented.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the engineer to stop train NY-12 west of signal 3272E as required by signal indication, and the inability of the crew in the caboose of train NY-12 to take preventive action.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board, on April 28, 1976, submitted the following recommendation to the Federal Railroad Administration:

"Insure that switches in signal territory are so protected that related signals governing train movements will display their most restrictive aspects if the switch points do not close properly. (R-76-15) (Class I, Urgent Followup)"

The National Transportation Safety Board also submitted the following recommendations to the Federal Railroad Administration:

"Promulgate rules to require engine crews to communicate fixed signal aspects to conductors while trains are en route on signalized track. (R-76-50) (Class II, Priority Followup)

"Promulgate rules to require the engine crew of a train to exchange signals with engine crews of passing trains and/or wayside employees. If passing crews do not acknowledge the signal, the responsive engine crew or wayside employee shall notify the dispatcher and/or conductor of the nonresponsive engine crew for corrective action. (R-76-51) (Class II, Priority Followup)"

In addition to these recommendations, the Safety Board reiterates the following recommendations which were made to the Federal Railroad Administration as a result of other train collisions:

"In cooperation with the Association of American Railroads, develop a fail-safe device to stop a train in the event that the engineer becomes incapacitated by sickness or death, or falls asleep. Regulations should be promulgated to require installations, use, and maintenance of such a device. (R-76-8)" (Issued 3/25/76)

"Include in its present investigation of the safety of locomotive-control compartments a study of environmental conditions that could distract crews from their duties or cause them to fall asleep at the controls. Regulations should be promulgated to correct any undesirable conditions disclosed. (R-73-9)" (Issued 5/3/73)

"In the promulgation of regulations governing railroad operating rules, where responsibility for safety operation of the train is assigned jointly to the engineer and the conductor, require that they be located and informed so that they can make quick effective decisions. (R-73-11)" (Issued 5/3/73)

"Promulgate regulations to require an adequate backup system for mainline freight trains that will insure that a train is controlled as required by the signal system in the event the engineer fails to do so. (R-76-3)" (Issued 1/25/76)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

September 10, 1976

NATIONAL TRANSPORTATION SAFETY BOARD
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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN ON BURLINGTON NORTHERN RAILROAD

NEAR RALSTON, NEBRASKA

DECEMBER 16, 1976

REPORT NUMBER: NTSB-RAR-77-8

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10. Work Unit No. 2192
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Railroad Accident Report December 16, 1976
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

About 2:45 a.m., on December 16, 1976, 1 SDP-40F locomotive unit and 11 cars of Amtrak train No. 6 derailed when leaving a 2°30' curve on the Burlington Northern track near Ralston, Nebraska. Forty-eight of the 178 passengers, and 15 of the 19 crewmembers on the train were injured. Property damage was estimated to be $816,000.

The National Transportation Safety Board determines that the probable cause of this accident was the lateral movement of the high rail and widening of track gage when the deteriorated crossties were unable to withstand the lateral forces generated by the locomotive while the train was traveling at a speed of 53 mph. Contributing factors were the weakened crosstie spikehole condition and the existing wide gage that conformed to the Federal Track Safety Standards for Class 4 track.

As a result of its investigation of the accident the National Transportation Safety Board submitted four recommendations to the Federal Railroad Administration concerning its track safety standards.

17. Key Words		18. Distribution Statement
Amtrak; derailment; track standards; track gage; track alignment; crossties; track spiking; lateral rail movement.		This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: October 6, 1977

DERAILMENT OF AMTRAK TRAIN ON BURLINGTON NORTHERN RAILROAD RALSTON, NEBRASKA DECEMBER 16, 1976

SYNOPSIS

About 2:45 a.m., on December 16, 1976, 1 SDP-40F locomotive unit and 11 cars of Amtrak train No. 6 derailed when leaving a 2°30' curve on the Burlington Northern track near Ralston, Nebraska. Forty-eight of the 178 passengers, and 15 of the 19 crewmembers on the train were injured. Property damage was estimated to be $816,000.

The National Transportation Safety Board determines that the probable cause of this accident was the lateral movement of the high rail and widening of track gage when the deteriorated crossties were unable to withstand the lateral forces generated by the locomotive while the train was traveling at a speed of 53 mph. Contributing factors were the weakened crosstie spikehole condition and the existing wide gage that conformed to the Federal Track Safety Standards for Class 4 track.

INVESTIGATION

The Accident

At 2:05 a.m., on December 16, 1976, eastbound Amtrak train No. 6, consisting of 2 SDP-40F locomotive units and 11 cars, departed Lincoln, Nebraska, en route to Chicago, Illinois, on Burlington Northern (BN) track. The crew consisted of 5 BN crewmembers and 14 Amtrak employees.

When train No. 6 was 2.4 miles west of Ralston, Nebraska, and leaving a 2°30' curve at a speed of 53 mph, an emergency application of the brakes occurred. The engineer stated that when he felt the unexpected braking, he immediately moved the automatic brake handle to the full-service position and released the engine brakes.

The throttle was in the sixth power position before the emergency application. Neither the engineer nor the fireman looked into their rearview mirror while traversing the curve. Neither heard unusual noises or felt unusual motions in the locomotive before the emergency brake application.

When the train stopped about 2:45 a.m., the conductor informed the engineer that the train had derailed. The engineer radioed the dispatcher at Lincoln to report the derailment and to request assistance. The second locomotive unit and all 11 cars derailed. The locomotive and first six cars remained upright on the track structure. The last five cars, which included the dome car, lounge car, dining car, and two sleeping cars, separated from the lead portion of the train. Three of the cars tipped on their sides and stopped about 40 feet down an embankment. The two sleeping cars on the rear remained upright and leaning. (See figure 1.)

The track is a series of curves for several miles leading to the derailment site at milepost 26.8. The track alignment immediately approaching the point of derailment consists of a 3,687-foot compound curve of 2°25.5', 2°32', and 2°29.5'. The length of the west spiral at the beginning of the curve was 338 feet and the length of the east spiral at the end of the curve was 200 feet. The superelevation of the curve was from 3 1/2 inches to 4 inches. There is an ascending 1.0 percent to level grade between mileposts 28 and 27. At milepost 27 the grade descends at 0.5 percent for 500 feet and then ascends at 0.4 percent for 550 feet to the point of derailment. The track is constructed on a fill up to the point of derailment, then on a short side hill cut at the point of derailment, and then on another fill. At the time of the accident, the roadbed was frozen.

The track was constructed of 136-pound, 39-foot rails connected with 6-hole 36-inch, head-free joint bars. Each rail was box anchored with 14 anchors. The rails rested on 8-inch by 14-inch, double-shoulder, 1-in-40 canted tie plates, which were laid on an average of twenty-two 7-inch by 9-inch by 8 1/2-foot oakwood crossties per 39-foot rail. The crossties were not doweled or provided with end anti-splitting devices. The crossties rested on about 12 inches of 3 1/2-inch crushed rock with about 10 inches of shoulder ballast. The rail was held with two 5/8-inch by 6-inch cut track spikes per tie plate.

The rail in the track was new when laid in 1963. The last extensive crosstie replacement, which averaged 781 crossties per mile, was made in 1972. The track in the curve leading to the derailment area was last surfaced and lined in 1975, and from the end of the curve eastward in November 1976. At that time an elevation runoff was made about two to four rails east of the point of derailment. On October 26, 1976, two adjacent low-side rails in the curve at the point of derailment were replaced due to vertical split head defects. The track gage was checked when the rails were replaced and was found to be 3/4 inch to 7/8 inch wider than standard gage of 4 feet 8 1/2 inches. The replacement rails were installed closer to the high-side rail to make the gage only 1/2 inch wider than standard. The two replacement rails were not spiked into the same tie plate and crosstie spikeholes as the old rails. The spikeholes were not filled with tie plugs. No work was performed on the two opposite high-side rails while regaging the track.

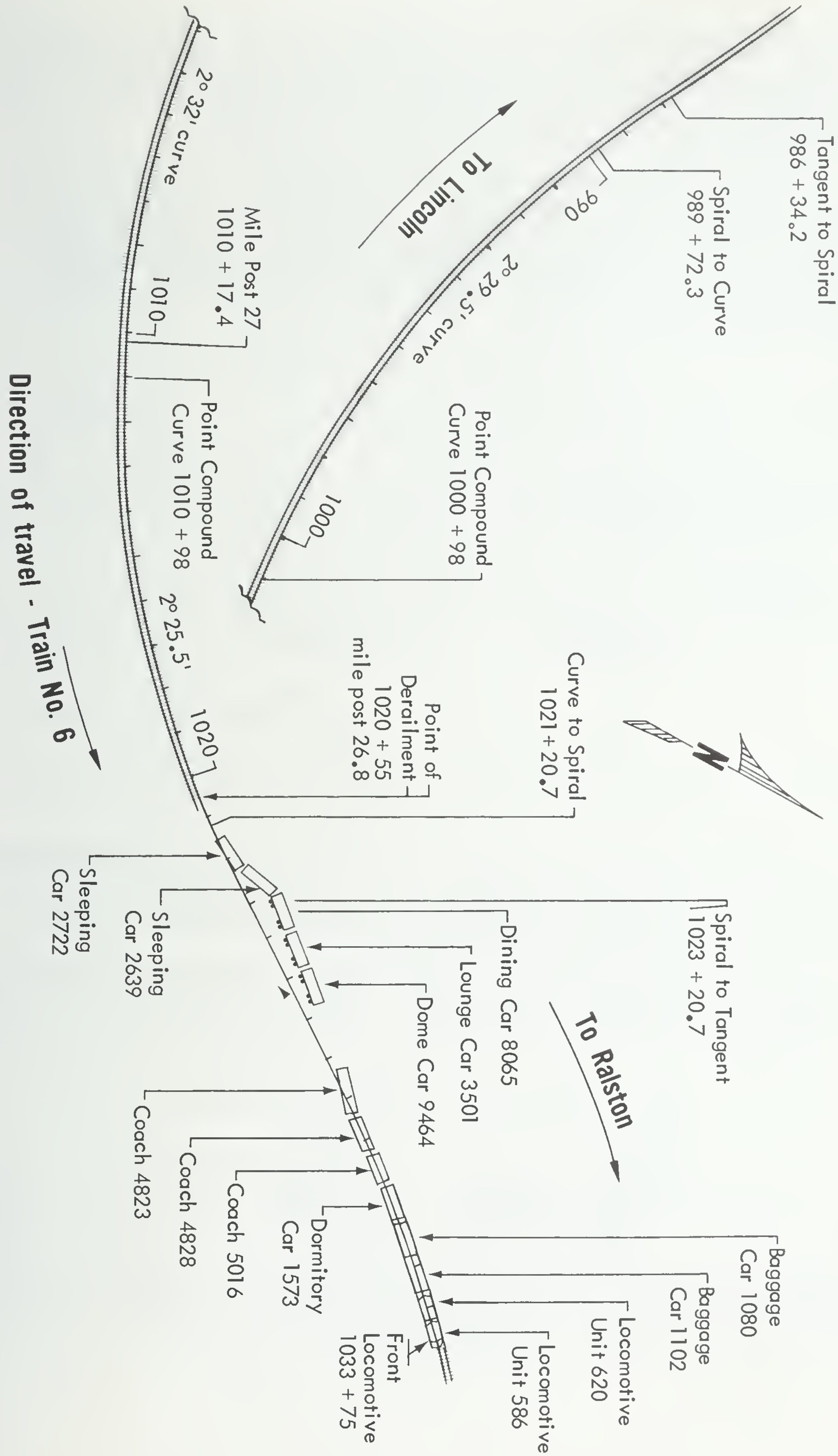


Figure 1. Plan of accident site.

On August 9, 1976, the BN track geometry car was used to inspect the track, and an excessive 3° alignment variation was detected in the derailment area. However, track inspectors stated they could not visually detect the variation, so no corrective action was taken.

The track in the derailment area is classified as Class 4. This classification requires that the track be inspected by the railroad twice weekly with at least one calendar day interval between inspections. The last track inspection made 2 days before the derailment did not disclose any visible conditions that did not comply with the Federal Track Safety Standards.

During the 24-hour period before the derailment, five eastbound and four westbound trains moved through the derailment area. Their maximum speeds were 38 mph westbound and 43 mph eastbound for freight trains, and 38 mph westbound and 54 mph eastbound for passenger trains. The traincrews did not report any irregularities in the track or in the riding quality of their equipment.

Injuries to Persons

Injuries	Crewmembers	Passengers	Other
Fatal	0	0 1/	0
Nonfatal	15	48	0
None	4	130	

Damage

The rear truck of the second locomotive unit was moderately damaged. The cars sustained mostly truck damage. The three cars that tipped on their sides had some exterior denting and moderate interior damage.

The derailment damaged 1,250 feet of track. There was extensive crosstie damage and moderate rail damage. Cost of damages was estimated to be as follows:

Cars	$ 725,000
Locomotive	18,000
Track	19,000
Signal	12,000
Removal of Wreck	42,000
Total	$ 816,000

1/ One passenger who was hospitalized on December 16, 1976, died on December 28, 1976, before hospital discharge.

Train Information

The train consisted of two locomotive units, two baggage cars, a dormitory car, three coaches, a dome car, a lounge car, a diner, and two sleeping cars. The passenger cars were constructed of stainless steel and were equipped with tightlock couplers. The SDP-40F diesel-electric locomotive units were manufactured by the Electro-Motive Division of the General Motors Corporation. The lead unit weighed 378,140 pounds, and the second unit weighed 385,000 pounds. Each unit had two 3-axle trucks and was equipped with dynamic brakes, No. 26L airbrake system, an alertor-type safety device, speedometer, speed recorder, and radio with which the locomotive crewmembers could communicate with crewmembers on the train, on other trains, and with the dispatcher.

Method of Operation

Trains are operated over this portion of single track between Lincoln and Ralston, Nebraska, by signals of a traffic control system. The system is controlled by the dispatcher in Lincoln, Nebraska. The maximum authorized speed for passenger trains in this territory is 79 mph with a 55 mph restriction through the compound curve at the derailment site. Freight trains are restricted to a maximum of 50 mph through the compound curve.

Meteorological Information

The accident occurred at night. The weather was clear, and the temperature was 22° F.

Survival Aspects

Deputy sheriffs arrived at the scene about 2:55 a.m. and immediately alerted all rescue units in the area. Within 10 minutes, rescue units from six nearby communities responded. The law enforcement agencies, emergency rescue units, Amtrak and BN personnel evacuated the passengers from the train within 45 minutes. Evacuation of most passengers was not difficult except for those in the four cars that were leaning or on their sides. The passengers in these cars had to crawl over partitions, through aisles, and break windows to escape.

Most passengers were sleeping at the time of the accident and were located in the coaches, dome car, and sleeping cars. The injuries to passengers consisted of broken bones, back injuries, hip injuries, abdominal injuries, cuts, abrasions, and concussions. One passenger suffered serious internal injuries and bleeding. Passengers complained that they were thrown from their seats, hit by luggage, or struck their heads or bodies on fixtures and partitions.

Tests and Research

The lead locomotive unit stopped 1,315 feet beyond the first indications of the derailment. Wheel marks were found on the gage side of the railhead and on the rail base of the low north rail, beginning 80 feet west of the point of curve to spiral. About 27 feet east of the point of derailment, both the north and south rails were moved and tipped outward to the point where the locomotive stopped.

Inspection of the curved track westward from the point of derailment disclosed variations in alignment, gage, superelevation, crosstie conditions and tie plate movement. Alignment mid-ordinate measurements from a 62-foot chord varied from 2 inches to 3 1/2 inches. Gage varied consistently from 1/4 inch to 7/8 inch wider than standard gage of 4 feet 8 1/2 inches. Superelevation of the curve varied from 3 1/4 inches to 4 1/8 inches to 3 1/2 inches in the 600 feet approaching the point of derailment. The crossties under the high south rail in the 54 feet preceding the point of derailment showed evidence of spikehole elongations and deterioration, end splitting, and tie plate movement without rail tipping. The tie plate movement varied progressively from 1/8 inch to 5/8 inch in the first 23 feet, and then in the next 31 feet from 1/16 inch to 1 7/8 inches at the point of derailment. (See appendix A.) None of these alignment, gage, superelevation, or tie plate movement measurements were taken under the static or dynamic loading of a train. All measurements taken after the derailment, except tie plate movement, complied with the Federal track standards for Class 4 track.

The 26 crossties leading to the point of derailment were visually examined by investigators. The age of the crossties could not be determined; however, one crosstie had a datemark of 1952. Thirteen crossties exhibited high-rail end splitting of 1 foot or more from their ends to the tie plate and spikehole locations. Two of these crossties exhibited some tie plate cutting and six had been adzed by hand. Two other crossties exhibited substantial checking, and one crosstie had a beveled edge which decreased the width of the high-rail tie plate bearing area to 7 1/2 inches.

Four of the 26 crossties that were removed from the track for further testing exhibited 2-inch to 3-inch spikehole elongations toward the field side. Several spikehole elongations were located in the end splitting cracks. The prebored spikeholes indicated that the crossties had never been respiked in the other spikeholes before the derailment. After the derailment, the other spikeholes were used when rebuilding and regaging the track. Four crossties, which were sawed in two at the edge of the spikehole locations, exhibited full heartwood and some softness in the spikeholes. Track spikes could be removed by hand from two of these crossties. According to the Federal Track Safety Standards, only 2 of the 26 crossties visually inspected were considered defective because they were "impaired to the extent that [they] will not hold spikes."

An examination of the rail for wear at the point of derailment indicated that the high south rail had normal curve wear of about 3/16 inch and the low rail exhibited slight head flattening and metal flow toward the field side. Low-rail, gage-side track spikes were raised progressively to 1 1/4 inches above the base of rail beginning 34 feet west of the point of derailment.

Investigators found marks on only the rear wheels of the trailing truck of the second locomotive unit, indicating this was the first and only locomotive truck to derail. All locomotive truck measurements were within the design specifications and tolerances. One mechanical defect was found on each locomotive unit's No. 1 truck; the securement bolts were missing, for some time prior to the derailment, on the bolster connection end of the lateral hydraulic shock absorbers on the left front position.

The speed recorders on the locomotive units were checked for accuracy and the recorder on the second unit, which was the only unit provided with a tape, was found to be malfunctioning. Tests performed by the railroad and manufacturer, and witnessed by investigators, determined that the recorded speed of 73 mph at the time of derailment was 20 mph faster than the actual speed because of an improper calibration between the speedometer and the speed recorder.

ANALYSIS

As train No. 6 moved eastward through the curve on which it derailed, the outside rail moved laterally under the lateral force of the locomotive units. This force caused a progressive widening of track gage. The marks on the gage side of the low rail, and on the north wheel of the leading axle of the trailing truck of the second locomotive unit, indicated that this wheel dropped off the low rail when the track gage had widened sufficiently. Twenty-seven feet farther eastward, the low rail was pushed outward and tipped by the derailed wheel. At this point the south wheel on the trailing lead axle dropped from the high rail forcing both rails to spread and allowing the following locomotive and car wheels to drop inside of the gage.

When the track structure became sufficiently disturbed, the seventh and following cars began to go down the north embankment. This caused a coupler assembly to pull out between the sixth and seventh cars. The seventh, eighth, and ninth cars tipped on their sides as they came to rest on the slope of the embankment. The 165-foot gap between the sixth and seventh cars developed as the lead portion of the train continued eastward within the track structure.

According to the Federal Track Safety Standards for Class 4 track, gage must not become greater than 4 feet 9 1/2 inches, and the superelevation shall not deviate more than 1 1/4 inches from the designated

elevation. (See appendix B.) The 3 3/4-inch average superelevation of the curve was 1 1/4 inch greater then the FRA-required 2 1/2-inch elevation for a 55-mph maximum speed. However, the minimum 3 1/4-inch to maximum 4 1/8-inch superelevation measurements were within the allowable 1 1/4-inch deviation from the 3 1/2-inch, BN-designated elevation. According to BN track standards, this 3 1/2-inch superelevation allows a greater speed of 60 mph through the 2°30' curve for passenger trains, but restricts freight trains to 50 mph. The extra elevation aids equilibrium but places additional stress on the low rail by the slower-than-50-mph, heavy-tonnage freight trains. The effect of this stress could have contributed to the vertical split heads found in the low rails that were replaced at the point of derailment.

The force on the low rail would also contribute to loosening and raising of the gage-side track spikes. Any previous regaging and respiking in the same spikeholes could have lessened the holding ability of new spikes installed without tie plugs on the recently replaced rails. The fact that several track spikes could be removed by hand, particularly in freezing weather, also makes the crosstie spike-holding ability questionable.

The rail and tie plate movement measured at the point of derailment indicates a weakened crosstie condition and an inability of the two track spikes holding the high rail to withstand the lateral force induced by locomotive trucks. The crosstie spikehole elongations also indicate that the shear and crushing strength of the wood fibers in the spikehole areas had been exceeded. A number of these elongations were in the cracks of the crossties that exhibited end splitting and which did not have anti-splitting devices. The probability that the high-rail movement and spikehole elongations were developing months before the derailment is indicated by the 3° alignment deviation detected by the BN track geometry car in August 1976. The inability of the track forces to visually detect this alignment deviation can be attributed to the fact that the lateral movement of the rail occurred only under the dynamic loading of a train.

Another indication of the possible development of prior rail movement and spikehole deterioration is the 1/4 inch to 7/8 inch wider than standard gage measured throughout the curve after the derailment. Even though these variations did not exceed the 1-inch maximum wide gage, allowed by Federal Track Safety Standards, they indicate crosstie spikehole deterioration. To allow track gage to progressively widen through years of service, particularly beyond 1/2 inch, without regaging the track or taking other corrective measures is a questionable maintenance practice for track used by heavy, high-speed trains. To allow the track gage to change as much as 3/8 inch and 1/2 inch in only 19 1/2 feet is also a questionable track condition which could cause sudden locomotive truck oscillations. The

phenomenon of lateral rail movement (gage widening) under the dynamic loading of a train has been experienced by other railroads which have conducted gage-widening tests. 2/

Alignment measurements taken throughout the curve indicate that the degree of curve had increased in sharpness to about 2°45' in the body and to 3°14' near the spiral-to-curve location at the west end. This alignment change, particularly at the ends of the curve, was due to the flexibility in the track and the increased lateral force transmitted by trains as they entered the curve and as their motion changed from linear to rotational. Under the dynamic force of a train during nonfreezing weather, the rail, tie plate, track spike and crosstie tend to work as a unit and will move together and transfer the force to the yielding ballast. However, in freezing weather the crosstie will normally not move in the frozen ballast and more of the lateral force has to be absorbed by the crosstie in the spikehole locations. 3/ Consequently, with the passage of each train through the curve, it is evident that the enlarged and weakened spikeholes in the crossties at the point of derailment were subjected to an increasing rate of stress and deterioration.

Since the amount of force transmitted to the crosstie is basically related to the weight and speed of a train, a train with the heaviest locomotive units and the highest speed will induce the largest force. Therefore, with continued spikehole weakening, it was a matter of time until such a train moving through the curve at the point of derailment induced the force necessary to sufficiently widen track gage and cause its own derailment. When train No. 6 approached the point of derailment on December 16, its SDP-40F locomotive units were of the heaviest type operating over this section of track, and since it was a passenger train, it was traveling near the maximum authorized track speed of 55 mph.

The securement bolts missing from the left lateral hydraulic shock absorber on the No. 1 truck of each locomotive unit may have affected the locomotive ride quality and oscillation due to deficient snubbing. Since the engineer and fireman did not feel any unusual motions before or during the derailment, the effect of any oscillations on the locomotive trucks appears to have been minimal. Also with these units operating in this condition through curves before the derailment, any adverse effects would have been transferred to the track structure at other locations. At the point of derailment, however, any adverse effects could have acted as a contributing factor on a weakened track condition.

2/ The Union Pacific Railroad issued a report of its "Wide-Gage Investigation of the Track Train Dynamic Program" in 1974. The Louisville and Nashville Railroad reported on tests of gage-holding on curves in 1972.

3/ Union Pacific Railroad "Wide-Gage Investigation of the Track Train Dynamic Program," 1974.

The type of passenger equipment on train No. 6 did not permit rapid escape for passengers or rapid access for rescue personnel. When the cars tipped on their sides, passengers had great difficulty getting down stairways and climbing over partitions. In other cars, scattered luggage and jammed doorways made escape difficult. Passengers and rescue personnel had to break windows in order to evacuate several cars.

Since 1970 the Safety Board has investigated 24 accidents involving railroad, commuter, and rapid transit passenger cars. Recommendations fostered by these accidents were made concerning the lack of crashworthiness in rail cars. Recommendation BSTS-70-R-10, June 10, 1970, to the Federal Railroad Administration (FRA) recommends "that the Federal Railroad Administration initiate studies to determine the relationship between rail passenger car design and passenger injury and, where practical, take action for correction in the design of future high-speed and rapid transit passenger cars." The FRA has initiated studies but these studies have not yet been completed or evaluated by the FRA.

CONCLUSIONS

Findings

1. The crewmembers operated train No. 6 in accordance with applicable BN rules.

2. Track gage progressively widened when the high rail moved laterally as the first three trucks of the locomotive passed over it. As a result, the fourth truck derailed from the low rail.

3. At the point of derailment, the spikeholes in the crossties were being progressively elongated and the wood fibers were being overstressed for several months before the accident.

4. The shear and crushing strength of a timber crosstie in the spikehole location may be exceeded under dynamic forces of heavy axle loads, particularly with a frozen ballast condition and only two rail-holding track spikes per tie plate.

5. The absence of anti-splitting devices in the oak crossties allowed end splitting in spikehole locations which weakened crosstie gage-holding ability.

6. The track in the 40 feet leading to the point of derailment had critical crosstie, gage, and alignment conditions that developed under the dynamic loading of a train. These conditions were not ascertained by using procedures in the Federal Track Safety Standards.

7. The 1 inch wider than standard gage allowed in Class 4 curve track permits excessive spikehole elongation and deterioration for the dynamic forces imposed by heavy, high-speed locomotives and trains.

8. A timber crosstie need not be impaired to the extent it will literally not hold track spikes to be defective. A certain degree of spikehole deterioration and looseness can allow a track spike to become ineffective in holding adequate track gage in a high-speed curve.

9. There are no methods or quantitative values listed in the Federal Track Safety Standards for determining when timber crossties have been impaired by the dynamic forces of various types of trains to the extent that they will not hold track spikes adequately.

10. There is a need to establish criteria for track inspectors, other than existing personal subjective evaluations, for determining if timber crossties will hold track spikes or gage adequately.

11. Lateral tie plate movement can occur under the dynamic force of a train and not be readily detected in track with or without a static load.

12. A weakened track condition may have been affected by locomotive body and truck oscillations which were not adquately dampened due to deficient snubbing.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the lateral movement of the high rail and widening of track gage when the deteriorated crossties were unable to withstand the lateral forces generated by the locomotive while the train was traveling at a speed of 53 mph. Contributing factors were the weakened crosstie spikehole condition and the existing wide gage that conformed to the Federal Track Safety Standards for Class 4 track.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board submitted the following recommendations to the Federal Railroad Administration:

> "Develop methods and criteria for track inspectors to determine when timber crossties are impaired by inservice dynamic forces to the extent that they do not adequately hold track spikes. (Class II, Priority Followup) (R-77-32)

"Amend track geometry standard 49 CFR 213.53 Gage, so that it establishes a maximum rate-of-change in track gage. (Class II, Priority Followup) (R-77-33)

"Amend track structure standard 49 CFR 213.109 (b-2) Crossties, so that it is possible to obtain a standard and effective inservice evaluation of the subjective assessment of 'A timber crosstie is considered to be defective when it is ...impaired to the extent it will not hold spikes.' (Class II, Priority Followup) (R-77-34)

"Investigate and test to determine if timber crosstie track spiking requirements as contained in track structure standard 49 CFR 213.127 are adequate for the tonnage and speed of present locomotives and trains. (Class II, Priority Followup) (R-77-35)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

WILLIAM R. HALEY, Member, did not participate.

October 6, 1977

APPENDIX A

TRACK MEASUREMENTS

STATION	** MID-ORDINATE	GAGE	ELEVATION	
986+03	4/16"	4'-9"		Tangent
+20 Jt*	4/16	4-9 1/4		
986+34				pt. of Spiral (west end of curve)
+40	0	4-9		
+60 Jt	0	4-8 7/8		
+80	0	4-9		
987+00 Jt	0	4-9		
+19	0	4-8 7/8		
+38 Jt	7/16	4-8 7/8		
+58	8/16	4-8 7/8		
+77 Jt	6/16	4-9		
+98	7/16	4-8 7/8		
988+15 Jt	11/16	4-8 15/16	13/16"	
+35	12/16	4-9	1 7/16	
+55 Jt	12/16	4-9 1/16	1 13/16	
+75	14/16	4-8 7/8	2 3/8	
+94 Jt	16/16	4-9 1/16	2 5/8	
989+14	22/16	4-8 7/8	3 1/8	
+33 Jt	40/16	4-9 3/8	3 1/4	7/8" wide gage
+53	48/16	4-9 3/16	3 5/8	
989+72 Jt	40/16	4-9 3/16	3 7/8	Pt. of curve
+92	37/16	4-9 1/8	4	
990+11 Jt	39/16	4-9 3/16	3 3/4	
+31	38/16	4-9	3 3/4	
+50 Jt	47/16	4-9 1/16	3 3/8	
+70	48/16	4-8 7/8	3 3/8	
990+89 Jt	51/16	4-9	3 3/8	
991+09	47/16	4-9 1/4	3 3/4	
+28 Jt	42/16	4-8 7/8	3 5/8	
+48	33/16	4-8 3/4	3 7/8	
+67 Jt	34/16	4-9	3 3/8	
+87	41/16	4-8 7/8	3 3/8	
992+06 Jt	44/16	4-8 7/8	3 1/2	
+26	45/16	4-8 5/8	3 3/4	
+45 Jt	39/16	4-8 3/4	3 5/8	
+65	35/16	4-8 7/8	4	
+84 Jt	36/16	4-9	3 7/8	
993+03	40/16	4-8 7/8	3 7/8	
+22 Jt	44/16	4-9	3 5/8	
+42	43/16	4-8 7/8	3 7/8	

* Jt: Rail Joint Location
** Mid-Ordinate measurement using a 62-foot chord

TRACK MEASUREMENTS

STATION	MID-ORDINATE	GAGE	ELEVATION	
+61 Jt	40/16	4-8 3/4	3 5/8	
+81	43/16	4-8 3/4	3 3/4	
994+00 Jt	45/16	4-9	3 1/4	
+20	40/16	4-9	3 3/4	
+40 Jt	40/16	4-9	3 3/4	
+60	38/16	4-8 3/4	3 5/8	
+79 Jt	40/16	4-9	3 3/8	
+98	43/16	4-8 7/8	3 5/8	
995+17 Jt	42/16	4-8 7/8	3 1/2	
+37	41/16	4-8 3/4	3 3/4	
+56 Jt	42/16	4-8 7/8	3 3/8	
+76	40/16	4-8 7/8	3 3/4	
995+95 Jt	40/16	4-8 3/4	3 5/8	
996+15	40/16	4-9	3 5/8	
+34 Jt	40/16	4-9	3 3/4	
+54	39/16	4-8 7/8	3 7/8	
+73 Jt	38/16	4-8 5/8	3 1/2	
+93	40/16	4-8 7/8	3 5/8	
997+12 Jt	43/16	4-9 1/8	3 3/4	
+32	41/16	4-8 3/4	3 3/4	
+51 Jt	40/16	4-8 3/4	3 7/8	
+71	39/16	4-8 3/4	3 5/8	
+90 Jt	37/16	4-8 5/8	2 7/8	
998+10	46/16	4-8 7/8	4	
+29 Jt	44/16	4-8 7/8	3 5/8	
+49	39/16	4-8 3/4	3 3/4	
+68 Jt	39/16	4-8 7/8	3 3/4	
+88	40/16	4-9 1/8	4 1/16	
999+07 Jt	42/16	4-9 1/4	3 3/4	
+27	43/16	4-8 7/8	3 3/4	
+46 Jt	42/16	4-9	3 3/4	
+66	42/16	4-8 7/8	3 7/8	
+85 Jt	41/16	4-8 7/8	3 5/8	
1000+05	41/16	4-8 3/4	3 3/4	
+24 Jt	43/16	4-8 7/8	3 5/8	
+44	42/16	4-8 7/8	3 3/4	
+63 Jt	44/16	4-8 7/8	3 3/4	
+83	42/16	4-8 3/4	3 3/4	
1000+98				$2^{o}25.5'$ Pt. Compound Curve $2^{o}32'$
1001+02 Jt	41/16	4-8 7/8	3 5/8	
+22	41/16	4-8 5/8	3 5/8	
+41 Jt	43/16	4-8 7/8	3 3/4	
+61	41/16	4-8 3/4	3 7/8	
+80 Jt	40/16	4-8 3/4	3 7/8	

TRACK MEASUREMENTS

STATION	MID-ORDINATE	GAGE	ELEVATION
+99	43/16	4-8 3/4	4
1002+19 Jt	44/16	4-8 3/4	3 7/8
+39	44/16	4-8 7/8	4 1/16
+58 Jt	40/16	4-8 5/8	3 7/8
+78	39/16	4-8 7/8	4
+97 Jt	40/16	4-9	3 3/4
1003+17	43/16	4-8 7/8	3 7/8
+36 Jt	44/16	4-8 7/8	3 3/4
+56	43/16	4-8 3/4	4
+75 Jt	47/16	4-8 7/8	3 3/4
+95	41/16	4-8 7/8	4
1004+14 Jt	42/16	4-8 15/16	3 7/8
+34	43/16	4-8 3/4	4 5/16
+53 Jt	44/16	4-8 7/8	3 7/8
+73	42/16	4-9	4 5/16
+92 Jt	45/16	4-8 3/4	3 3/4
1005+11	43/16	4-9	4
+30 Jt	42/16	4-9	3 3/4
+50	44/16	4-8 7/8	3 7/8
+70 Jt	43/16	4-8 3/4	3 5/8
+89	41/16	4-8 7/8	3 3/4
1006+08 Jt	41/16	4-9	3 5/8
+28	42/16	4-8 7/8	3 5/8
+48 Jt	49/16	4-9 1/8	3 3/8
+68	44/16	4-9 1/8	3 3/4
+87 Jt	37/16	4-8 3/4	3 5/8
1007+06	40/16	4-8 7/8	3 5/8
+25 Jt	43/16	4-9	3 1/2
+45	43/16	4-9	3 7/8
+65 Jt	41/16	4-9	3 5/8
+84	42/16	4-8 7/8	3 5/8
1008+03 Jt	39/16	4-9	3 5/8
+23	41/16	4-8 7/8	3 5/8
+42 Jt	46/16	4-9 1/8	3 1/2
+62	46/16	4-8 7/8	3 3/4
+82 Jt	45/16	4-8 3/4	3 3/4
1009+01	45/16	4-8 3/4	3 3/4
+20 Jt	39/16	4-9	3 1/2
+40	28/16	4-8 7/8	3 7/8
+59 Jt	46/16	4-9	3 1/4
+79	56/16	4-8 3/4	3 1/4
+99 Jt	46/16	4-8 5/8	2 5/8
1010+19	43/16	4-8 7/8	3 1/4
+38 Jt	42/16	4-8 3/4	3 5/8
+58	42/16	4-9	3 3/4
+77 Jt	45/16	4-9 1/16	3 5/8

TRACK MEASUREMENTS

STATION	MID-ORDINATE	GAGE	ELEVATION	
+96	44/16	4-8 7/8	3 7/8	
1010+98				$2^{o}32'$ Pt. Compound Curve
1011+15 Jt	37/16	4-8 3/4	5 9/32	$2^{o}29.5'$
1011+35	32/16	4-8 3/4	4 3/32	
+55 Jt	39/16	4-9 1/8	3 3/4	
+74	45/16	4-9 1/16	3 3/4	
+93 Jt	50/16	4-9	3 5/8	
1012+13	47/16	4-9	3 5/8	
+32 Jt	41/16	4-8 7/8	3 3/4	
+52	40/16	4-8 7/8	4	
+71 Jt	37/16	4-9	4	
+91	37/16	4-8 7/8	4 5/16	
1013+10 Jt	38/16	4-9 1/4	3 7/8	
+30	39/16	4-9 3/16	4 3/32	
+49 Jt	49/16	4-8 15/16	3 3/4	
+69	50/16	4-9	3 5/8	
+89 Jt	36/16	4-8 15/16	3 1/2	
1014+08	41/16	4-9	3 3/4	
+27 Jt	50/16	4-9	3 1/8	
+47	46/16	4-9 1/8	3 3/8	
+66 Jt	33/16	4-9	3 3/4	
+86	35/16	4-8 15/16	3 7/8	
1015+05 Jt	44/16	4-9 1/16	3 1/2	
+25	47/16	4-8 15/16	3 1/2	
+44 Jt	43/16	4-8 7/8	3 1/2	
+64	42/16	4-9	3 3/4	
+83 Jt	40/16	4-9 1/16	3 3/4	
1016+03	42/16	4-9 1/16	3 7/8	
1016+22 Jt	41/16	4-9 1/8	3 7/8	
+42	38/16	4-9	4	
+61 Jt	45/16	4-9 1/16	4	
+80	41/16	4-9	3 7/8	
+99 Jt	39/16	4-9 1/8	3 3/4	
1017+19	42/16	4-8 7/8	4	
+39 Jt	42/16	4-8 5/8	3 7/8	
+59	44/16	4-8 3/4	4	
+78 Jt	40/16	4-9	3 7/8	
+98	42/16	4-8 7/8	4 3/32	
1018+17 Jt	43/16	4-8 15/16	3 7/8	
+37	44/16	4-9	4	
+56 Jt	41/16	4-9	4	
+76	43/16	4-8 7/8	4	
+95 Jt	40/16	4-9	4	

TRACK MEASUREMENTS

STATION	MID-ORDINATE	GAGE	ELEVATION	
1019+15	40/16	4-8 7/8	4 3/32	
+34 Jt	46/16	4-9	4 3/32	
+54	45/16	4-9 1/16	4 3/32	
+73 Jt	42/16	4-9	3 7/8	
+93	42/16	4-9	4	
1020+12 Jt	28/16	4-8 7/8	3 3/8	
+32	*Disturbed track,			
+51 Jt	*area of tie plate			
1020+55	*movement, and			Pt. of
+75 Jt	*derailment.			Derailment
+95	*			
1021+15 Jt	*			
1021+21	*			Pt. Curve to Spiral
1023+21	*			Pt. Spiral to tangent

APPENDIX B

EXCERPTS FROM

TRACK SAFETY STANDARDS

FEDERAL RAILROAD ADMINISTRATION

DEPARTMENT OF TRANSPORTATION

SUBPART A—GENERAL

§ 213.1 SCOPE OF PART.

This part prescribes initial minimum safety requirements for railroad track that is part of the general railroad system of transportation. The requirements prescribed in this part apply to specific track conditions existing in isolation. Therefore, a combination of track conditions, none of which individually amounts to a deviation from the requirements in this part, may require remedial action to provide for safe operations over that track.

§ 213.9 CLASSES OF TRACK: OPERATING SPEED LIMITS.

(a) Except as provided in paragraph (b) of this section and § § 213.57(b), 213.59(a), 213.105, 213.113 (a) and (b), and 213.137 (b) and (c), the following maximum allowable operating speeds apply:

[In miles per hour]

Over track that meets all of the requirements prescribed in this part for —	*The maximum allowable operating speed for freight trains is —*	*The maximum allowable operating speed for passenger trains is —*
Class 1 track . .	10	15
Class 2 track . .	25	30
Class 3 track . .	40	60
Class 4 track . .	60	80
Class 5 track . .	80	90
Class 6 track . .	110	110

(b) If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements of this part. However, if it does not at least meet the requirements for class 1 track, no operations may be conducted over that segment except as provided in § 213.11.

§ 213.13 MEASURING TRACK NOT UNDER LOAD

When unloaded track is measured to determine compliance with requirements of this part, the amount of rail movement, if any, that occurs while the track is loaded must be added to the measurement of the unloaded track.

SUBPART C—TRACK GEOMETRY

§ 213.51 SCOPE.

This subpart prescribes requirements for the gage, alinement, and surface of track, and the elevation of outer rails and speed limitations for curved track.

§ 213.53 GAGE.

(a) Gage is measured between the heads of the rails at right angles to the rails in a plane five-eighths of an inch below the top of the rail head.

(b) Gage must be within the limits prescribed in the following table:

Class of track	*The gage of tangent track must be—*		*The gage of curved track must be—*	
	At least—	*But not more than—*	*At least—*	*But not more than—*
1	4'8"	4'9¾"	4'8"	4'9¾"
2 and 3	4'8"	4'9½"	4'8"	4'9¾"
4	4'8"	4'9¼"	4'8"	4'9½"
5	4'8"	4'9"	4'8"	4'9½"
6	4'8"	4'8¾"	4'8"	4'9"

§ 213.63 TRACK SURFACE.

Each owner of track to which this part applies shall maintain the surface of its track within the limits prescribed in the following table:

Track Surface	*Class of track*					
	1	*2*	*3*	*4*	*5*	*6*
The runoff in any 31 feet of rail at the end of a raise may not be more than	3½"	3"	2"	1½"	1"	½"
The deviation from uniform profile on either rail at the midordinate of a 62-foot chord may not be more than	3"	2¾"	2¼"	2"	1¼"	½"
Deviation from designated elevation on spirals may not be more than	1¾"	1½"	1¼"	1"	¾"	½"
Variations in cross level on spirals in any 31 feet may not be more than	2"	1¾"	1¼"	1"	¾"	½"
Deviation from zero cross level at any point on tangent or from designated elevation on curves between spirals may not be more than	3"	2"	1¾"	1¼"	1"	½"
The difference in cross level between any two points less than 62 feet apart on tangents and curves between spirals may not be more than	3"	2"	1¾"	1¼"	1"	⅝"

§ 213.55 ALINEMENT.

Alinement may not deviate from uniformity more than the amount prescribed in the following table:

Class of track	*Tangent track* — *The deviation of the mid-offset from 62-foot line*[1] *may not be more than—*	*Curved track* — *The deviation of the mid-ordinate from 62-foot chord*[2] *may not be more than—*
1	5"	5"
2	3"	3"
3	1¾"	1¾"
4	1½"	1½"
5	¾"	⅝"
6	½"	⅜"

[1] The ends of the line must be at points on the gage side of the line rail, five-eighths of an inch below the top of the railhead. Either rail may be used as the line rail, however, the same rail must be used for the full length of that tangential segment of track.

[2] The ends of the chord must be at points on the gage side of the outer rail, five-eighths of an inch below the top of the railhead.

§ 213.57 CURVES; ELEVATION AND SPEED LIMITATIONS.

(a) Except as provided in § 213.63, the outside rail of a curve may not be lower than the inside rail or have more than 6 inches of elevation.

(b) The maximum allowable operating speed for each curve is determined by the following formula:

$$V_{max} = \sqrt{\frac{E_a + 3}{0.0007d}}$$

where

V_{max} = Maximum allowable operating speed (miles per hour).

E_a = Actual elevation of the outside rail (inches).

d = Degree of curvature (degrees).

Appendix A is a table of maximum allowable operating speed computed in accordance with this formula for various elevations and degrees of curvature.

§ 213.59 ELEVATION OF CURVED TRACK; RUN-OFF.

(a) If a curve is elevated, the full elevation must be provided throughout the curve, unless physical conditions do not permit. If elevation runoff occurs in a curve, the actual minimum elevation must be used in computing the maximum allowable operating speed for that curve under § 213.57(b).

(b) Elevation runoff must be at a uniform rate, within the limits of track surface deviation prescribed in § 213.63, and it must extend at least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

APPENDIX A—
MAXIMUM ALLOWABLE OPERATING SPEEDS FOR CURVED TRACK

Elevation of outer rail (inches)

Degree of Curvature	0	½	1	1½	2	2½	3	3½	4	4½	5	5½	6
	Maximum allowable operating speed (mph)												
0°30′	93	100	107										
0°40′	80	87	93	98	103	109							
0°50′	72	78	83	88	93	97	101	106	110				
1°00′	66	71	76	80	85	89	93	96	100	104	107	110	
1°15′	59	63	68	72	76	79	83	86	89	93	96	99	101
1°30′	54	58	62	66	69	72	76	79	82	85	87	90	93
1°45′	50	54	57	61	64	67	70	73	76	78	81	83	86
2°00′	46	50	54	57	60	63	66	68	71	73	76	78	80
2°15′	44	47	50	54	56	59	62	64	67	69	71	74	76
2°30′	41	45	48	51	54	56	59	61	63	66	68	70	72
2°45′	40	43	46	48	51	54	56	58	60	62	65	66	68
3°00′	38	41	44	46	49	51	54	56	58	60	62	64	66
3°15′	36	39	42	45	47	49	51	54	56	57	59	61	63
3°30′	35	38	40	43	45	47	50	52	54	55	57	59	61
3°45′	34	37	39	41	44	46	48	50	52	54	55	57	59
4°00′	33	35	38	40	42	44	46	48	50	52	54	55	57
4°30′	31	33	36	38	40	42	44	45	47	49	50	52	54
5°00′	29	32	34	36	38	40	41	43	45	46	48	49	51
5°30′	28	30	32	34	36	38	40	41	43	44	46	47	48
6°00′	27	29	31	33	35	36	38	39	41	42	44	45	46
6°30′	26	28	30	31	33	35	36	38	39	41	42	43	45
7°00′	25	27	29	30	32	34	35	36	38	39	40	42	43
8°00′	23	25	27	28	30	31	33	34	35	37	38	39	40
9°00′	22	24	25	27	28	30	31	32	33	35	36	37	38
10°00′	21	22	24	25	27	28	29	31	32	33	34	35	36
11°00′	20	21	23	24	26	27	28	29	30	31	32	33	34
12°00′	19	20	22	23	24	26	27	28	29	30	31	32	33

SUBPART D—TRACK STRUCTURE

§ 213.101 SCOPE.

This subpart prescribes minimum requirements for ballast, crossties, track assembly fittings, and the physical condition of rails.

§ 213.109 CROSSTIES.

(a) Crossties may be made of any material to which rails can be securely fastened. The material must be capable of holding the rails to gage within the limits prescribed in § 213.53 (b) and distributing the load from the rails to the ballast section.

(b) A timber crosstie is considered to be defective when it is—

(1) Broken through;

(2) Split or otherwise impaired to the extent it will not hold spikes or will allow the ballast to work through;

(3) So deteriorated that the tie plate or base of rail can move laterally more than one-half inch relative to the crosstie;

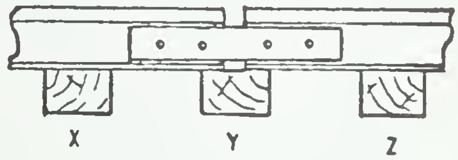
(4) Cut by the tie plate through more than 40 percent of its thickness; or

(5) Not spiked as required by § 213.127.

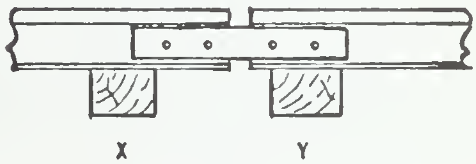
(c) If timber crossties are used, each 39 feet of track must be supported by nondefective ties as set forth in the following table:

Class of track	*Minimum number of nondefective ties per 39 feet of track*	*Maximum distance between nondefective ties (center to center) (inches)*
1	5	100
2, 3	8	70
4, 5	12	48
6	14	48

(d) If timber ties are used, the minimum number of nondefective ties under a rail joint and their relative positions under the joint are described in the following chart. The letters in the chart correspond to letter underneath the ties for each type of joint depicted.



Supported joint



Suspended joint

Class of Track	*Minimum number of nondefective ties under a joint*	*Required position of nondefective ties*	
		Supported Joint	*Suspended Joint*
1	One	X, Y, or Z	X or Y.
2, 3	One	Y	X or Y.
4, 5, 6	Two	X and Y, or Y and Z.	X and Y.

(e) Except in an emergency or for a temporary installation of not more than 6 months duration, crossties may not be interlaced to take the place of switch ties.

SUBPART F—INSPECTION

§ 213.231 SCOPE.

This subpart prescribes requirements for the frequency and manner of inspecting track to detect deviations from the standards prescribed in this part.

§ 213.233 TRACK INSPECTIONS.

(a) All track must be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under § 213.7.

(b) Each inspection must be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this part. However, mechanical or electrical inspection devices approved by the Federal Railroad Administrator may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 miles per hour when passing over track crossings, highway crossings, or switches.

(c) Each track inspection must be made in accordance with the following schedule:

Class of track	*Type of Track*	*Required frequency*
1, 2, 3 . . .	Main track and sidings.	*Weekly* with at least 3 calendar days interval between inspections, or *before use,* if the track is used less than once a week, or *twice weekly* with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year.
1, 2, 3 . . .	Other than main track and sidings.	*Monthly* with at least 20 calendar days interval between inspections.
4, 5, 6		*Twice weekly* with at least 1 calendar day interval between inspections.

(d) If the person making the inspection finds a deviation from the requirements of this part, he shall immediately initiate remedial action.

§ 213.237 INSPECTION OF RAIL

(a) In addition to the track inspections required by § 213.233, at least once a year a continuous search for internal defects must be made of all jointed and welded rails in Classes 4 through 6 track, and Class 3 track over which passenger trains operate. However, in the case of a new rail, if before installation or within 6 months thereafter it is inductively or ultrasonically inspected over its entire length and all defects are removed, the next continuous search for internal defects need not be made until 3 years after that inspection.

(b) Inspection equipment must be capable of detecting defects between joint bars, in the area enclosed by joint bars.

(c) Each defective rail must be marked with a highly visible marking on both sides of the web and base.

§ 213.239 SPECIAL INSPECTIONS.

In the event of fire, flood, severe storm, or other occurrence which might have damaged track structure, a special inspection must be made of the track involved as soon as possible after the occurrence.

§ 213.241 INSPECTION RECORDS.

(a) Each owner of track to which this part applies shall keep a record of each inspection required to be performed on that track under this subpart.

§ 213.113 DEFECTIVE RAILS.

(a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated under § 213.7 shall determine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until—

(1) The rail is replaced; or

(2) The remedial action prescribed in the table is initiated (next page):

(b) If a rail in classes 3 through 6 track or class 2 track on which passenger trains operate evidences any of the conditions listed in the following table, the remedial action prescribed in the table must be taken:

Condition	Remedial action: If a person designated under § 213.7 determines that condition requires rail to be replaced	Remedial action: If a person designated under § 213.7 determines that condition does not require rail to be replaced
Shelly spots; Head checks; Engine burn (but not fracture); Mill defect	Limit speed to 20 m.p.h. and schedule the rail for replacement.	Inspect the rail for internal defects at intervals of not more than every 12 mths.
Flaking; Slivered; Corrugated; Corroded	do	Inspect the rail at intervals of not more than every 6 mths.

(c) As used in this section—

(4) "Vertical Split Head" means a vertical split through or near the middle of the head, and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

§ 213.127 TRACK SPIKES.

(a) When conventional track is used with timber ties and cut track spikes, the rails must be spiked to the ties with at least one line-holding spike on the gage side and one line-holding spike on the field side. The total number of track spikes per rail per tie, including plate-holding spikes, must be at least the number prescribed in the table on following page:

(b) A tie that does not meet the requirements of paragraph (a) of this section is considered to be defective for the purposes of § 213.109 (b).

MINIMUM NUMBER OF TRACK SPIKES PER RAIL PER TIE, INCLUDING PLATE-HOLDING SPIKES

Class of track	Tangent track and curved track with not more than 2° of curvature	Curved track with more than 2° but not more than 4° of curvature	Curved track with more than 4° but not more than 6° of curvature	Curved track with more than 6° of curvature
1	2	2	2	2
2	2	2	2	3
3	2	2	2	3
4	2	2	3 — — —	— — —
5	2	3 — — —	— — —	— — —
6	2 — — —	— — —	— — —	— — —

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RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD

NEW CASTLE, ALABAMA

JANUARY 16, 1977

REPORT NUMBER: NTSB-RAR-77-9

UNITED STATES GOVERNMENT

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15. Supplementary Notes		

16. Abstract

About 4:15 a.m., on January 16, 1977, 1 locomotive unit and 12 cars of Amtrak train No. 315 derailed on the Louisville and Nashville Railroad Company's track near New Castle, Alabama. Seventy-six of the 129 persons on board the train were injured. Property and equipment damage was estimated to be $578,000.

The National Transportation Safety Board determines that the probable cause of this accident was the tipping of the east rail which caused the track gage to widen. The gage widened because the track structure was not able to withstand the lateral forces generated by oscillations of the locomotive trucks as the train moved around a 5° curve. The oscillations were generated by variations in track alignment and superelevation that complied with Federal Track Safety Standards for Class 3 track and by the ineffectiveness of a vertical snubbing device on the second locomotive unit.

As a result of the investigation of the accident, the National Transportation Safety Board submitted two recommendations to the Federal Railroad Administration regarding operation of SDP-40-F locomotives, and one recommendation to the National Railroad Passenger Corporation.

17. Key Words Amtrak; derailment; track alignment; track gage; super-elevation; equilibrium speed; lateral/vertical ratio.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: October 20, 1977

DERAILMENT OF AMTRAK TRAIN ON LOUISVILLE AND NASHVILLE RAILROAD NEW CASTLE, ALABAMA JANUARY 16, 1977

SYNOPSIS

About 4:15 a.m., on January 16, 1977, 1 locomotive unit and 12 cars of Amtrak train No. 315 derailed on the Louisville and Nashville Railroad Company's track near New Castle, Alabama. Seventy-six of the 129 persons on board the train were injured. Property and equipment damage was estimated to be $578,000.

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INVESTIGATION

The Accident

At 12:29 a.m., on January 16, 1977, southbound Amtrak train No. 315 departed Nashville, Tennessee, for Wildwood, Florida, with a consist of 2 SDP-40-F locomotive units, 11 Amtrak cars, and 9 auto-train cars. The train was operated daily between Chicago, Illinois, and Wildwood. Between Nashville and Birmingham, Alabama, the train was operated over the Louisville and Nashville Railroad (L&N) by an L&N crew.

The fireman, a qualified engineer, was operating the train as it approached New Castle, Alabama, 15.7 miles north of Birmingham. The train's speed had been reduced to 42 mph for about 1 mile before the train was to enter a 5° curve. The fireman again applied the brakes to slow the train to comply with a speed restriction. To maintain the prescribed 40 mph, the train brakes were released and the throttle placed in the No. 4 position. The throttle was then advanced to the No. 6 position because of a slightly ascending grade.

The fireman, who was viewing the train through the rearview mirror as it moved through the curve, saw sparks being generated under the rear truck of the second unit. He realized immediately that the train had derailed and made an emergency application of the brakes.

When the train stopped, the fireman went back to ascertain the severity of the derailment. The engineer remained in the cab of the lead locomotive unit, notified the train dispatcher of the derailment by radio, and requested that medical aid be dispatched to the scene.

The conductor, who was riding in car 11, the dining car, first became aware of the derailment by the emergency application of the brakes and the fire he saw toward the area of the locomotive. Immediately afterward, he felt the dining car derail. The flagman who was riding on the west side of the cupola of the caboose-type car at the rear end of the train saw fire in the vicinity of the locomotive.

No. 315 derailed as it moved around a 5° curve on an ascending grade of 0.4 percent at New Castle. The curve began 452 feet north of the derailment point and extended southward for 710 feet. The track was laid on a side-hill cut to the point of derailment and then southward on a fill which was 21 feet high at its midpoint. (See figure 1.)

The rear truck of the second locomotive unit, the following 12 cars and the lead truck of car 13 were derailed.

The track consisted of 132-lb RE, 39-foot rails connected by 6-hole, 36-inch joint bars. The rails rested on 7 7/8- by 14-inch, 1:40 canted double-shoulder, 8-hole tie plates and were supported by an average of 22, 9- by 7-inch by 8-foot 6-inch wooden crossties per 39-foot rail length. There was an average of two line-holding and one plate-holding spikes per tie plate; this exceeded the number of spikes required by the Federal Track Safety Standards for Class 3 track.

During July 1973, 1,225 timber ties were replaced in the mile leading to and around the curve. The curve was surfaced and superelevated 4 inches in December 1975. In July and August 1976, a maintenance crew raised low rail joints and performed other routine maintenance; no detailed records, however, were kept. On July 14, 1976, this section of track was inspected using an ultrasonic rail test car; no defects were detected. From January 1, 1976, through January 15, 1977, there were no reported rail failures. The track was last inspected on January 14, 1977. The L&N's track geometry bus charted the area of the derailment on July 21, 1976, and again on January 19, 1977. Results of these inspections indicated that the track conditions had not changed appreciably in the interim and that, except for the track disturbed during the derailment, it met the Federal Track Safety Standards for Class 3 track.

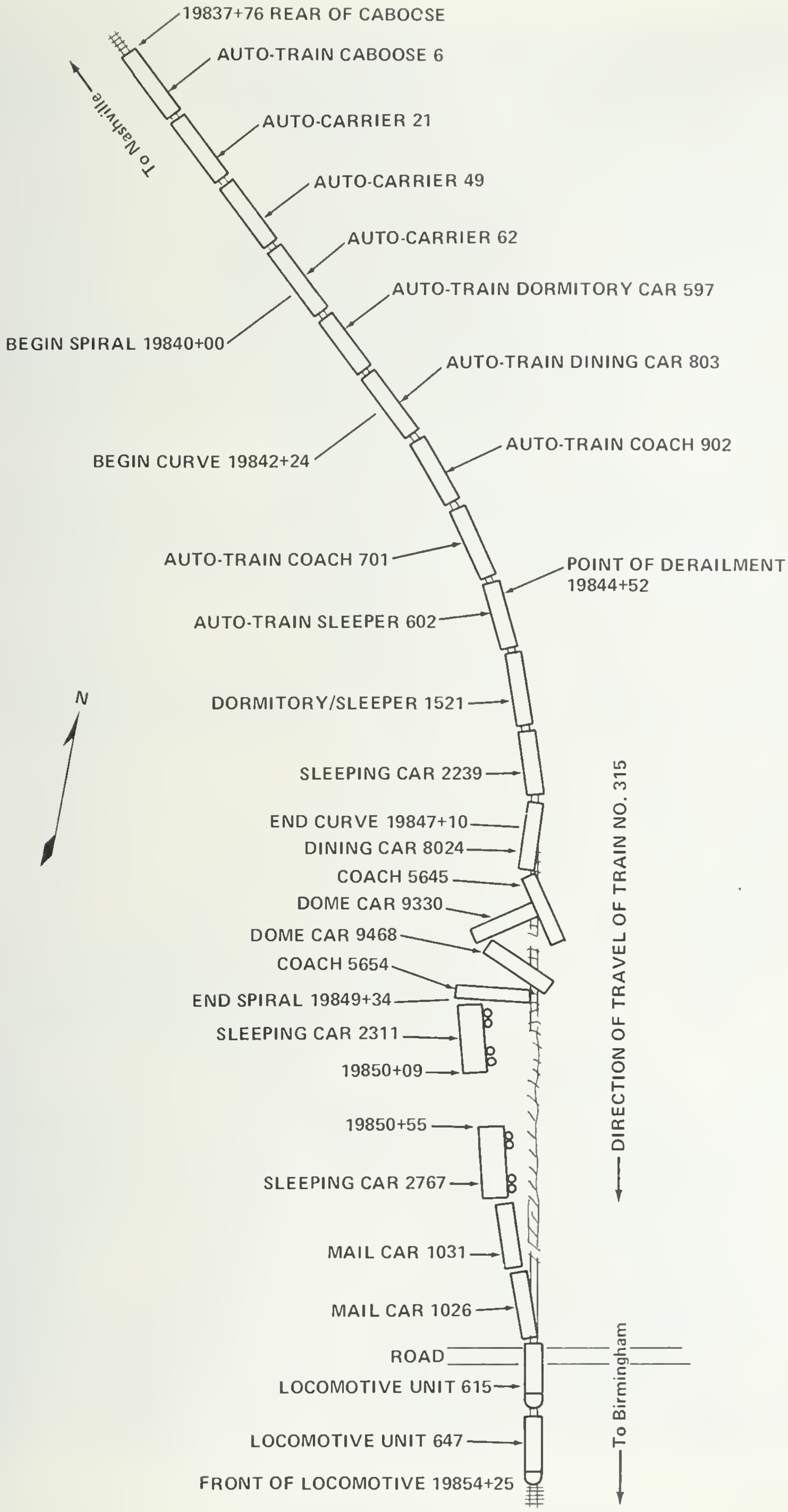


Figure 1. Plan of accident site.

Injuries to Persons

Injuries	Traincrew	Passengers	Service Personnel
Fatal	0	0	0
Nonfatal	0	68	8
None	5	43	5

Damage to Train and Track

The first locomotive unit was not damaged; the second unit sustained damage to its No. 2 truck. Three passenger cars were destroyed. Cost of damage to the other passenger cars varied between $3,000 and $60,000. The auto carriers were not damaged.

During the derailment, several cars separated and failed to remain in line because the shanks of their tightlock couplers fractured. The most serious of these separations resulted in the north end of the seventh car, a dome car, striking and destroying the windows and window posts on the west side of the eighth car, a coach. (See figure 2.)

The derailment destroyed about 850 feet of track. Several hundred feet of a carrier-owned telephone and communication lines adjacent to the track were damaged substantially.

Cost of damages were estimated as follows:

Cars	$564,900
Locomotive	1,500
Track	11,533
Clearing Wreckage	21,250
Total	$599,183

Method of Operation

Trains are operated in this area by signals of a traffic control system which is controlled by a dispatcher in Birmingham, Alabama. Maximum authorized speed was 70 mph, but was restricted to 40 mph on the curve on which the train derailed.

Train Information

The train consisted of two locomotive units coupled in multiple-unit control, two mail cars, five coaches, five sleeping cars, two dome cars, two dining cars, three autocarriers, and a caboose.

Figure 2. Damaged seventh and eighth cars (background) of train No. 315.

The locomotive units were Model SDP-40-F, manufactured by the ElectroMotive Division (EMD) of General Motors Corporation, and are rated at a maximum of 3,000 horsepower. They were equipped with two six-wheel trucks, each having three axle-hung, direct-current traction motors, the armatures of which are gear-connected to axles and 40-inch driving wheels. The units measured 72 feet 4 inches over coupler pulling faces and weighed 400,000 pounds. A 2,500-gallon fuel tank was hung under the frame. A 2,150-gallon water tank, also hung under the frame, and a 1,350-gallon deck-mounted water tank, supplied the steam generators.

Because of earlier derailments of trains with SDP-40-F locomotives units as they moved around curves of 2° or more, Amtrak had made several changes in the trucks; however, the second unit had not been modified. These modifications included: vertical snubbing units of increased capacity applied to each truck; secondary truck suspension changed to softer rubber springs; and, the clearance between the bolster and the truck frame increased.

All cars in the train were of standard steel construction. The autocarriers were enclosed triple-deck, flat cars. The entire consist was equipped with tightlock couplers.

Each locomotive unit was equipped with an electronic deadman control, a speed indicator, a speed recorder, and a radio. The conductor had a portable radio with which he could communicate with the enginecrew.

Meteorological Information

When the train derailed, lighting conditions were dark, the skies were cloudy, temperature was 29° F, and there were no reports of recent precipitation or any rapid change in the weather.

Survival Aspects

All of the injured were treated at the local hospitals. Two passengers were hospitalized immediately for treatment of heart conditions; one other was admitted later for a neck injury; all others were treated and released. Several persons were treated for window glass fragments in their eyes; however, the injuries of the other persons were confined to lacerations, bruises, and back and neck sprains which resulted from the passengers contact with the interior sides of the cars and the seats as the cars derailed. Most of the injured were in the dome car. The passengers who were in bed in the sleeping cars were not injured.

The inclination of the cars made evacuation difficult. However, there were no reports of injuries during rescue operations. Since several cars had run down the embankment and overturned, escape from these units was complicated by the need for removing people through windows or by the end doors. Movement through the interior of a passenger car that is laying on its side is hampered by seats and narrow aisleways. There was no fire.

Tests and Research

The lead locomotive unit stopped 973 feet beyond the derailment point. The east, or outside, rail of the curve was found to be tipped outward sufficiently at the derailment point to allow the west wheels of the trailing truck of the second locomotive unit to derail inside of the west rail. Marks on the rail indicated that the derailed wheels of the truck continued to spread the track until the train stopped. As the rails spread, the following cars derailed. Abrasive marks and gouges found on the wheels of the trailing truck of the second unit indicated that it was the first to derail. The tie plates had not moved laterally.

Inspection of the track north of the derailment area revealed irregularities in curvature, gage, and superelevation as follows:

1. Gage varied from standard 56 1/2 inches to 57 7/16 inches.

2. Curvature, when measured by using the midordinate measurement of a 62-foot chord, varied from a minimum of 4°15' to a maximum of 5°56'.

3. Superelevation varied from the designed 4 inches to between 4 and 5 inches.

All of the above deviations were within the requirements for Class 3 track. (See figure 3.) These measurements were taken with the track structure unloaded.

The two SDP-40-F locomotive units were moved to the L&N's shops in Louisville, Kentucky, where the units received detailed inspection and testing. A calibration test of the speed indicator and recorder indicated that a train speed of 42 mph resulted in an indicator speed of 40 mph and a recorder speed of 43 mph. The second unit was not supplied with a tape. The lead locomotive unit was thoroughly inspected and, except for being about 17 percent over horsepower, was found to be within design specification limits. Examination of the second unit revealed two defective components which were not considered to be the result of the accident. The wheel slip control module contained a loose wire which caused intermittant operation. The vertical snubbing device on the left side of the No. 2 truck was defective when it was operated in the compression mode.

ANALYSIS

Train No. 315 was being operated in compliance with L&N operating rules and instructions except that the speed limit on the curve was exceeded by 2 mph because of an error of the speed indicator in the locomotive. This overspeed by itself should not have contributed appreciably to the cause of the derailment.

A postaccident examination of the track indicated variations in line, gage, and elevation in the undisturbed track for 600 feet north of the point of derailment. Although the curve deviated from the planned 5° with 4 inches superelevation, these variations did not exceed those allowed by the Federal Track Safety Standards for Class 3 track. From 220 feet north to the point of derailment, track curvature varied from an approximate maximum of 5°45'; to a minimum of 4°15'; the greatest rate of change was within the last 100 feet before the point of derailment. Within this same area, superelevation varied from 4 1/4 inches to 4 3/4 inches, with the greatest rate of change 60 feet in approach to the point of derailment. In examining the relationship of the track's curvature to its elevation immediately prior to the point of derailment, as shown in figure 3, it is evident that the greatest variance occurred in the 200 feet before the derailment point. Many of these changes occurred in a short distance.

The L&N had prescribed an operating speed of 40 mph for passenger trains operating through the curve. Because of the error in the speed indicator, the train's speed was 42 mph as compared to the maximum speed of 43 mph allowed by 49 CFR 213.57b. The equilibrium speed for a train at the point of derailment should have been 34.6 mph. A 42-mph speed which exceeded equilibrium speed by 21 percent would result in an increased steady lateral loading on the outside rail. The SDP-40-F locomotive with three-axle truck normally exerts higher lateral forces on the outside rail of curves than other locomotives. The second unit had a defective vertical snubbing device on the trailing truck which decreased its vertical stability by an unknown value. The irregularities in the track geometry--surface, alignment, gage, and superelevation--would tend to generate additional lateral forces which are induced as impulses when the locomotive wheels strike the uneven points in the track geometry. If this results in an oscillatory harmonic effect, these impulses would be cumulative and add to those steady lateral forces already present. This could result in wide variations of the L/V ratio. (See appendix B.) The absence of lateral movement of the tie plates also suggests a diminishing of the vertical loading at the same time that a heavy lateral load was exerted on the head of the rail.

The facts indicate plainly that some force tilted outward the outside rail of the curve sufficiently to allow derailment. The sparks seen by the fireman through the rearview mirror were generated as the derailed wheels abraded the inside of the west rail.

The locomotive and the first, second, and third cars remained coupled. The severity of the derailment was probably increased by the terrain onto which the cars derailed. The cars trailed down the west side of the embankment producing stresses which broke the tightlock couplers of the fourth through eighth cars which permitted the cars to separate, overturn, and stop at various angles on, or near, the track structure.

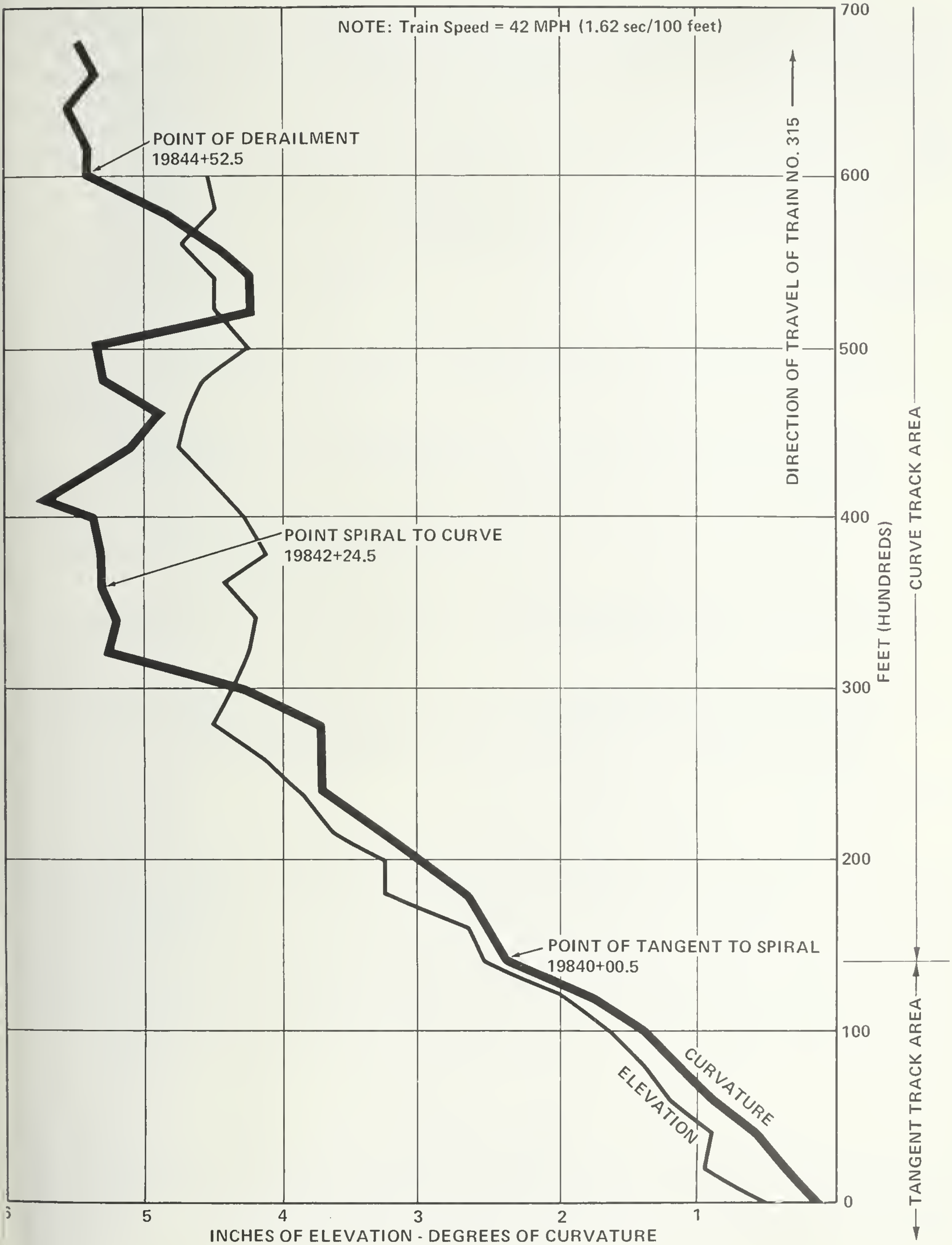


Figure 3. Deviations in curvature and superelevation.

Even though several of the passenger-carrying cars, after derailing, slid down the bank of the track structure and overturned, the passengers in these cars were not seriously injured. Most of their injuries were confined to lacerations and contusions which resulted from the passengers contacting the interior surfaces of the cars. This accident points out again that passengers who are not ejected from the cars in an accident tend to survive without critical injuries. Additional attention to the interiors of rail passenger cars will produce even better results.

CONCLUSIONS

Findings

1. The defective vertical snubbing device on the second locomotive unit decreased its trailing truck's vertical stability.

2. The track from 400 feet north to the derailment point contained variations in track alignment and superelevation which caused oscillations of the locomotive units which in turn developed a high L/V ratio.

3. The variations found in the track north of the derailment point were acceptable by the Federal Track Safety Standards.

4. The train exceeded the L&N speed restriction by 2 mph because of a speed indicator error as it entered the 5° curve on which it derailed.

5. The train's speed was calculated to be about 21 percent above the equilibrium speed for the 5° curve but was still within the maximum allowable speed by the Federal Track Safety Standards.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the tipping of the east rail which caused the track gage to widen. The gage widened because the track structure was not able to withstand the lateral forces generated by oscillations of the locomotive trucks as the train moved around a 5° curve. The oscillations were generated by variations in track alignment and superelevation that complied with Federal Track Safety Standards for Class 3 track and by the ineffectiveness of a vertical snubbing device on the second locomotive unit.

RECOMMENDATIONS

As a result of this investigation, and other investigations of derailments, the National Transportation Safety Board recommended on February 3, 1977, that the Federal Railroad Administration:

"Investigate immediately the interaction between SDP-40-F and P-30CH locomotives of passenger trains and track conditions to determine the causes for the widening of the track gage and act to correct the causes. (Class I, Urgent Followup) (R-77-1)

"Until such investigation and corrections are completed, restrict passenger trains with SDP-40-F locomotives to speeds that will permit safe operation around curves of 1°30' or more on Class 4 or less track. The speeds should not exceed the equilibrium speed on such curves. (Class I, Urgent Followup) (R-77-2)"

As a further result of this investigation, the Safety Board recommended on November 7, 1977, that the National Railroad Passenger Corporation:

"Establish inspection and repair procedures that will insure that locomotive units with defective truck components will not be dispatched. (Class II, Priority Followup) (R-77-36)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ JAMES B. KING
Member

October 20, 1977

APPENDIX A

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: February 3, 1977

REVISED: April 18, 1977

Forwarded to:

Honorable Asaph H. Hall
Administrator
Federal Railroad Administration
400 Seventh Street, S. W.
Washington, D.C. 20590

SAFETY RECOMMENDATION(S)

R-77-1 and 2

On January 16, 1977, the second locomotive unit and 12 cars of Amtrak train No. 57 derailed on the Louisville and Nashville Railroad Company track about 15 miles north of Birmingham, Alabama. The train, with SDP-40F-type locomotive units, was moving at a speed of 43 mph around a 5° curve; the superelevation of the curve was 4 inches, and the maximum allowable speed was 40 mph.

Seventeen trains with either the SDP-40F-type locomotive or the P-30CH-type have derailed since January 14, 1974. (See attachment.) Preliminary investigations of these accidents indicate that on curves which exceed 1°30' and which have certain deviations in track geometry, passenger train locomotives of the SDP-40F and P-30CH-types with 6-wheel trucks and which travel at speeds above 48 mph cause the outside rail to either move laterally or to tip outward. This permits the wheels of the locomotive and following cars to derail.

The gage widens even though the 6-wheel truck locomotives do not deviate from design standards, and inspections of the track indicate that it generally complies with the Federal Track Standard for the authorized speeds of the trains.

R-77-1 and 2

Therefore, the National Transportation Safety Board recommends that the Federal Railroad Administration:

> Investigate immediately the interaction between SDP-40F and P-30CH locomotives of passenger trains and track conditions to determine the causes for the widening of the track gage and act to correct the causes. (Class I, Urgent Followup)(R-77-1)

> Until such investigation and corrections are completed, restrict passenger trains with SDP-40F locomotives to speeds that will permit safe operation around curves of 1°30' or more on Class 4 or less track. The speeds should not exceed the equilibrium speed on such curves. (Class I, Urgent Followup) (R-77-2)

TODD, Chairman, BAILEY, Vice Chairman, McADAMS, HOGUE, and HALEY, Members, concurred in the above recommendations.

Kay Bailey

for Webster T. Todd, Jr.
Chairman

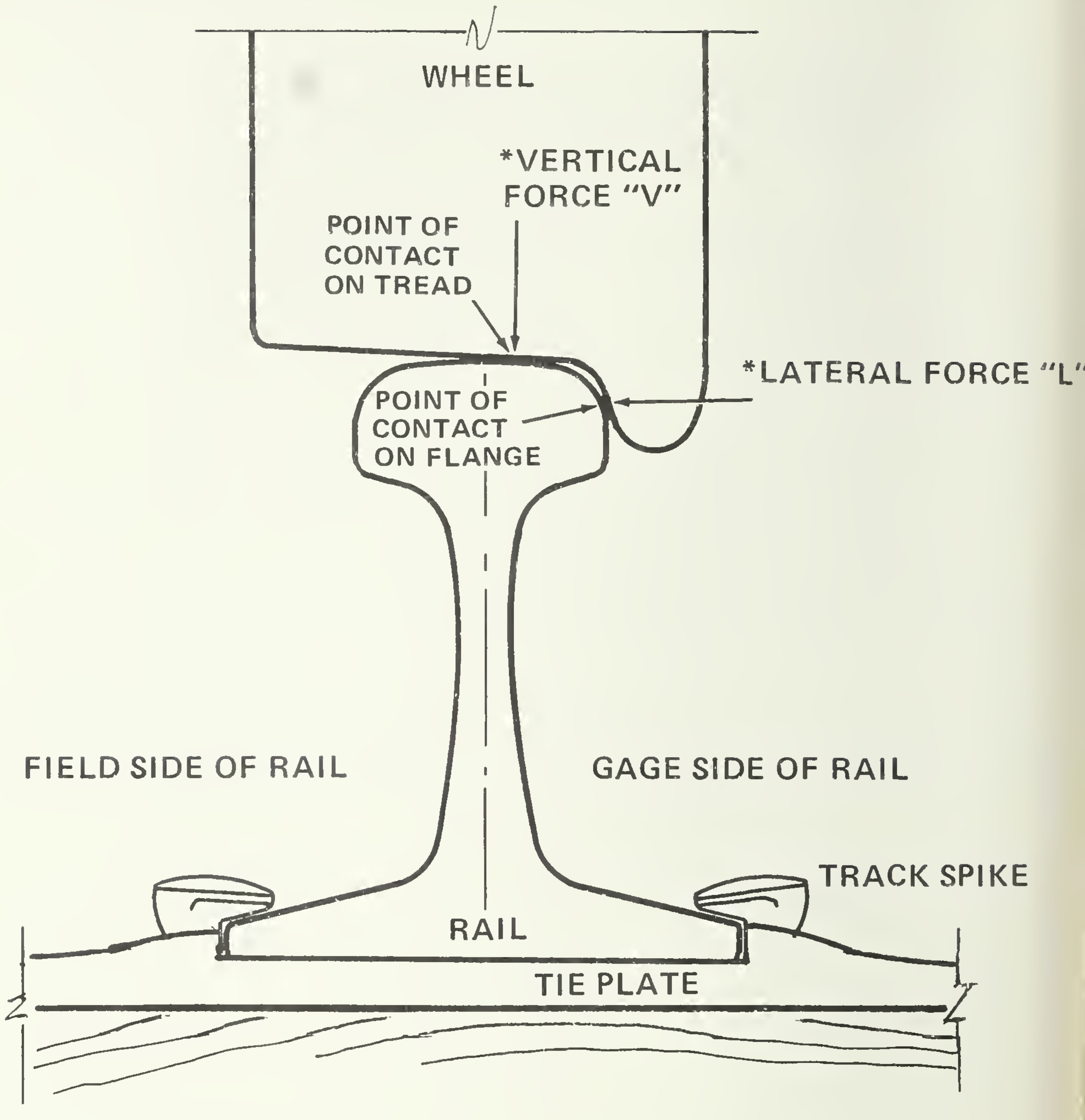
Attachment

R-77-1 and 2

Train derailments involving six-axle SDP-40F and P30CH locomotives:

	DATE	PLACE	RR	TRAIN	SPEED MPH	° CURVE OR TANGENT	TRACK CLASS
1.	12-16-76	Ralston, Neb.	BN	No. 6	53	$2^{\circ}30'$	4
2.	11-29-76	Sewell, W.Va.	C & O	No. 51	52	2°	4
3.	9-29-76	E. Sewell, W.Va.	C & O	No. 50	52	$2^{\circ}3'$	4
4.	9-9-76	Vaiden, Miss.	ICG	No. 59	79	$0^{\circ}30'$	4
5.	6-30-76	Goodman, Miss.	ICG	No. 59	88	Tangent	4
6.	1'-30-76	Shandon, Ohio	C & O	No. 51	50	4°	4
7.	1-24-76	Heath, Ohio	PC		70	Tangent	4
8.	1-5-76	Flynn, Mont.	BN	No. 10	60	$3^{\circ}22'$	4
9.	10-1-75	Pulaski, Tenn.	L & N	Floridian	60	$3^{\circ}8'$	4
10.	1-31-75	Huntington, W.Va.	C & O	No. 50	48	2°	4
11.	1-12-75	Castlerock, Wa.	BN	No. 11	59	$2^{\circ}32'$	4
12.	12-28-74	Mifflin, Pa.	PC	No. 40	55	2°	4
13.	8-12-74	Wake Forest, N.C.	SCL	No. 81	58	$3^{\circ}15'$	4
14.	7-16-74	Hartselle, Ala.	L & N	No. 316	60	$2^{\circ}4'$	4
15.	7-5-74	New Florence, Pa.	PC	No. 30	52	2°	4
16.	4-30-74	Winamac, Ind.	PC	No. 53	47	1°	3
17.	1-14-74	Ardmore, Okla.	AT & SF	No. 15	56	$3^{\circ}10'$	4

APPENDIX B



*The lateral to vertical ratio (L/V) is the lateral force pushing outward against the rail compared to the vertical force pushing downward on the top of the rail. The tendency for the rail to tip and/or move laterally, or for the wheel to climb the rail increases as the L/V ratio approaches unity.

Vertical forces due to the weight and movement of the train are transferred through the wheels of the locomotive and cars to the rail and tend to hold the rail in a vertical position on the tie plates, whereas whenever the wheel flanges come in contact with the side of the rail head as the train moves along the track they exert an overturning or tipping lateral force on the rail.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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RAILROAD ACCIDENT REPORT

CHICAGO AND NORTH WESTERN TRANSPORTATION COMPANY

FREIGHT TRAIN DERAILMENTS AND COLLISION

GLEN ELLYN, ILLINOIS

MAY 16, 1976

REPORT NUMBER: NTSB-RAR-77-2

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Railroad Accident Report May 16, 1976
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

About 4:25 a.m. on May 16, 1976, the locomotive and 27 cars of Chicago and North Western freight train No. 242 derailed as they moved eastward on a 1°54' to 2°15' compound curve just west of Glen Ellyn, Illinois. Another CNW freight train, No. 380, was moving eastward on an adjacent track at the time and struck the derailed cars of No. 242; the locomotive and nine cars of train No. 380 derailed. The tank-head of train No. 380's fifth car was punctured during the derailment by the coupler of an adjacent car; this released anhydrous ammonia into the atmosphere. Fourteen persons were injured as a result of the derailment and release of the ammonia. Damage from the accident was estimated to be $1,914,600.

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail of a 1°54' to 2°15' compound curve because the rail was unable to withstand the lateral forces of the locomotive induced by the speed of the train on track which did not comply with Federal Track Safety Standards.

17. Key Words Railroad accident; derailment, freight train; collision with derailed equipment; tankhead puncture; evacuation; anhydrous ammonia; hazardous materials.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.	
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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: March 31, 1977

CHICAGO AND NORTH WESTERN TRANSPORTATION COMPANY FREIGHT TRAIN DERAILMENTS AND COLLISION GLEN ELLYN, ILLINOIS MAY 16, 1976

SYNOPSIS

About 4:25 a.m., on May 16, 1976, the locomotive and 27 cars of Chicago and North Western Transportation Company (CNW) freight train No. 242 derailed as they moved eastward on a 1°54' to 2°15' compound curve just west of Glen Ellyn, Illinois. Another CNW freight train, No. 380, was moving eastward on an adjacent track at the time and struck the derailed cars of No. 242; the locomotive and nine cars of train No. 380 derailed. The tankhead of train No. 380's fifth car was punctured during the derailment by the coupler of an adjacent car; this released anhydrous ammonia into the atmosphere. Fourteen persons were injured as a result of the derailment and release of the ammonia. Damage from the accident amounted to $1,914,600.

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail of a 1°54' to 2°15' compound curve because the rail was unable to withstand the lateral forces of the locomotive induced by the speed of the train on track which did not comply with Federal Track Safety Standards.

INVESTIGATION

The Accident

On May 16, 1976, Extra 6923 East (No. 242), an eastbound Chicago and North Western Transportation Company (CNW) freight train, which consisted of 4 diesel-electric units, 43 cars, and a caboose, departed Clinton, Iowa, for Chicago, Illinois. The train had been inspected and tested before it had departed Fremont, Nebraska, and additional inspections and test were performed en route to Chicago. No discrepancies or malfunctions were found during any of the inspections. The crew was changed at West Chicago, 7.9 miles west of Glen Ellyn, Illinois, but the relieved locomotive crewmembers remained onboard in the second unit of the train. Train orders were issued which authorized No. 242 to operate at a speed of 60 mph between Geneva, 5 miles west of West Chicago, and Kedzie, near Chicago. No. 242 was the first eastbound freight train authorized to operate at that speed over this area under recently issued changes in CNW operating instructions.

About 4:25 a.m., No. 242 was moving about 60 mph on track 2, one of three main line tracks in Glen Ellyn, and began passing another eastbound freight train, Extra 873 East (No. 380), near College Avenue. The locomotive units and about 33 cars of No. 242 had passed the front end of No. 380 as No. 242 began to move around a curve to the right. The locomotive crew-members of No. 242 felt the locomotive lunge toward the north side and then toward the south side. The engineer looked rearward and saw fire coming from under either the rear locomotive unit or the first car. He reached for the brake valve but an emergency application of the brakes already had occurred.

The locomotive and first car separated from the train and continued eastward for about 2,400 feet where the car separated from the locomotive and stopped. The locomotive continued eastward another 2,200 feet. The next 26 cars of No. 242 derailed and obstructed track 3. The engineer of No. 242 immediately called the crew of No. 380 by radio to warn them of the accident.

Train No. 380, which consisted of 2 locomotive units and 63 cars, was moving eastward on track 3 at a speed of about 40 mph as No. 242 passed. When No. 380's engineer heard the warning of the derailment over the radio, he could not see the derailed cars because track 3 was the outside track on the curve. The engineer immediately made an emergency application of the brakes but the train's speed did not reduce substantially before the train collided with the derailed cars.

Glen Ellyn is located 22.4 miles west of Chicago. The 1°54' to 2°15' compound curve on which the accident occurred begins 5,297 feet west of Glen Ellyn and extends eastward for 2,813 feet. The grade for eastbound trains is 0.39 percent, descending, approaching the accident point.

Pennsylvania Avenue parallels the tracks on the north and several apartment houses are located on the north side of the avenue. Apartment houses and single-family dwellings are located along the south side of the tracks. (See figure 1.)

Track 2 consisted of 115-pound, continuously welded, 1,320-foot-long rail which was laid in 1967 on approximately 3,114 ties per mile. The rails were joined together by 36-inch, 6-hole, head-free joint bars and rested on 7 3/4-by 13-inch, 8-hole, double-shouldered tie plates. The rail was secured with two track spikes per plate around the compound curve and was box-anchored on alternate ties using 46 rail anchors per 39 feet of track. The track was ballasted with crushed quartzite to a depth of 14 inches below the bottom of each crosstie.

Although track 2 was constructed of continuously welded rail, there were numerous rail joints between College Avenue and the point of derailment. Several insulated joints were required for grade crossing protection. When the welded rail was installed, the CNW placed a buffer rail on one or both sides of each insulated joint; this resulted in additional rail joints.

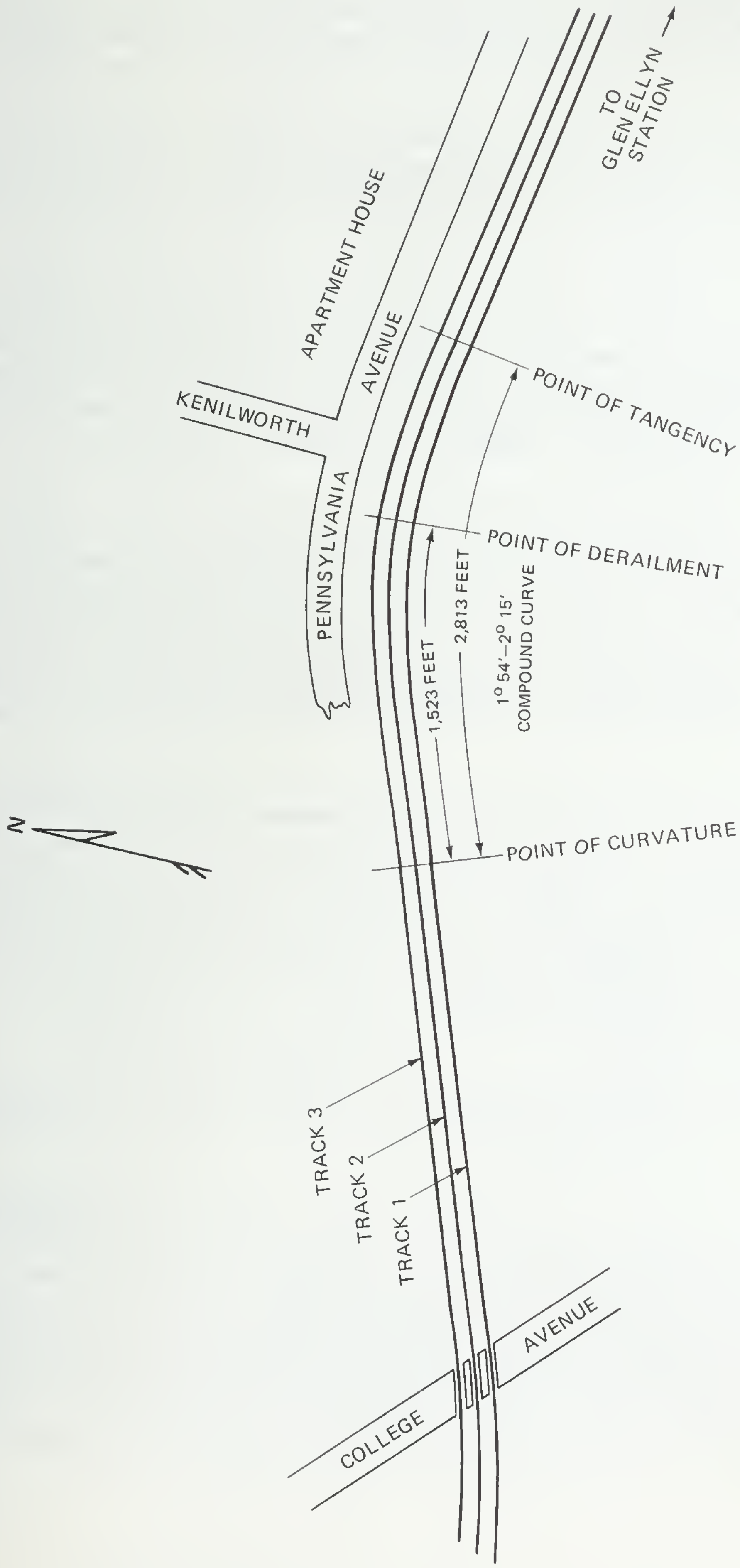

Figure 1. Plan of accident site.

The compound curve had a superelevation of about 4.9 inches. The gage of track 2 through the curve varied from 4 feet 8 1/2 inches to 4 feet 9 5/16 inches. Track 2 is classified as Class 4 under the Federal Track Safety Standards of the Federal Railroad Administration (FRA).

Injuries to Persons

Injuries	Crew	Passenger	Other
Fatal	0	0	0
Nonfatal	1	0	14
None	9	0	

No. 380's front brakeman, after hearing No. 242's warning on the radio, was injured when he climbed out of the side window of the locomotive and dropped to the ground. The engineer, who stayed in the cab, was not injured. Fourteen persons were treated for ammonia inhalation.

Damage to Trains

An examination of the locomotive of No 242 disclosed that three of the four units were damaged. On the second unit, the trailing wheel on the south side of the front truck had a mark on the outer rim which indicated that it derailed. Marks were found on the wheels of the rear truck of the third unit which indicated that it derailed and ran between the rails. Extensive damage was found on the underframe and on both trucks of the fourth unit.

Twenty-one flat cars loaded with trailers and 6 mechanical refrigerator cars of No. 242 derailed. The first car stopped upright on the track structure, 2,397 feet east of the derailment point. The other derailed cars stopped in various positions, on the track structure and on Pennsylvania Avenue. The 13th car crossed the avenue and struck the brick entrance to the parking lot of an apartment complex. The 15th car stopped on its side and a fire started near its refrigeration unit. The fire spread to a trailer before firemen extinguished it.

The locomotive units and first nine cars of No. 380 derailed and stopped in various positions on or adjacent to the tracks. They were heavily damaged.

The tankhead of the fifth car, PSPX 32028, a tank car loaded with 30,318 gallons of anhydrous ammonia, was punctured by the coupler of an adjacent car during the derailment. The anhydrous ammonia escaped from the 1/8-inch by 3-inch puncture and formed a vapor cloud. This car had not been provided with head shields or top and bottom shelf couplers. The car stopped at an angle of 25° with the damaged head slightly elevated.

Other Damage

The first marks of the derailment appeared on the gage side of the ball on the south rail of track 2, 1,523 feet east of the beginning of the curve; the marks extended for 4 feet 2 inches.

From this point neither rail showed any marks for 19 feet. Marks then appeared on the gage side of the ball of the north rail, followed by marks on the web on the gage side of the north rail. The north rail was broken 38 feet 6 inches east of the first mark on the web.

The north rail of track 2 was displaced to the north and stopped against the south end of the crossties on track 3 for a distance of 2,100 feet from the derailment point to the Prospect Avenue grade crossing. The south rail of track 2 was dislodged from its ties and tipped thoughout the same distance. The crossing flangeway rails in Prospect Avenue were shattered on the west end of the crossing.

The north side of the rails of track 2 showed wheel marks from the Prospect Avenue grade crossing east to the next crossing at Park Avenue. In this area the rail anchors and track spikes were damaged on both the south and north rails.

In addition to the damage to track 2, 546 feet of track 3 were destroyed. One rail of track 1 was tipped and the track's alignment was disrupted.

The surface of Pennsylvania Avenue and landscaping on nearby residential properties were damaged considerably.

Damaged-related cost was estimated as follows:

Equipment	$ 804,600
Lading	850,000
Track	92,000
Removal of Wreck	81,000
Surrounding Properties	62,000
Personal Claims	25,000
Total	$1,914,600

Train Information

The locomotive of No. 242 consisted of four SD-40-2 diesel-electric units which were rated at 3,000 horsepower, weighed 368,000 pounds each, and were provided with six-wheel trucks. The locomotive was equipped with cab signals, automatic train control, dynamic brakes, 26L-type airbrakes, automatic sanders, slip-slide detector, an operable radio, and a speed indicator but no speed recorder.

No defective conditions that would have caused or contributed to the cause of the accident were found on the locomotive units.

Method of Operation

In the accident area trains are operated by cab signal indications from an automatic block signal system. There are no wayside signals. The signal system is further supplemented by a two-position train control system. Track 3 is signalled for eastbound train movements and track 2 is signalled for movements in both directions.

The maximum authorized speed in this area is 60 mph for passenger trains and 40 mph for freight trains. The train control system has a high- and low-speed setting which corresponds to the allowable speed. Freight trains that meet certain standards are permitted by train order to operate at passenger train speeds.

Meteorological Information

The weather at the time of the accident was cloudy with scattered ground fog and a light southwest breeze. No precipitation fell during the day of the accident.

Tests and Research

Following the accident, an inspection of track 2 west of the accident site disclosed some defective conditions at the joint areas. One joint area, located on the superelevated north rail about 700 feet west of the derailment point had 170 inches between nondefective crossties. (See figure 2.) This track condition would not qualify for a FRA Class 1 designation, which permits a maximum freight train speed of only 10 mph. There were six additional crosstie defects at joints within 1,700 feet west of the derailment point that would meet only FRA Class 3 specifications which permit a maximum freight train speed of 40 mph. The six defects were deteriorated crossties or crossties that were not spiked to the rail in the joint area. (See appendix A for track measurements.)

The track measurements taken following the accident showed several locations within two rail lengths where the elevation varied from 1 1/2 inches to 1 3/4 inches from established elevation and in one location it varied 1 1/4 inches in one rail length. Several other locations had wood shims applied between the tie plates and the crossties at the joints to correct excessive changes in cross level. Some of the shims were not secured. (See figure 3.)

An equilibrium speed is produced when the result of the reaction of the unit's weight with centrifugal force is directed toward the center of the track. The superelevation required on a curve of 1°54' and of 2°15' at an equilibrium speed of 60 mph is 4.8 and 5.6 inches.

Figure 2. Defective crossties about 700 feet west of derailment point.

Figure 3. One of several joint locations with shims under tie plates.

The head of the 115-pound rail on track 2 on the north side of the curve was found to be worn about 8 percent.

The Association of American Railroads (AAR) analyzed the broken rail section of the elevated north rail of track 2. The AAR determined that the rail failed as a result of an impact on the gage side of the web; this probably occurred during the derailment.

Hazardous Material Information

Anhydrous ammonia, the chemical that was transported in PSPX 32028, is classified as nonflammable compressed gas under U.S. Department of Transportation safety regulations. About 20,000 gallons escaped through the punctured tankhead between the time of the derailment and 8:30 p.m. on May 16. The remaining 10,000 gallons were transferred into tank trailers brought to the accident site. The ammonia vaporized as it escaped. These ammonia fumes were dispersed by a southwesterly wind and engulfed the damaged tank car and the residential area along the tracks.

The derailment was observed by a Glen Ellyn police sergeant who notified the Dupage County Communications Center (DU-COMM) of the accident at 4:27 a.m. The fire department was dispatched immediately. The fire-chief reported that he arrived at the scene at 4:31 a.m.

After arriving, the firechief walked along Pennsylvania Avenue in the darkness, searching for injured train crewmen or bystanders. He detected the odor of ammonia as he reached the area near the parking lot of the apartment house. He was unable to see the source of the ammonia because of the fog, darkness, and wreckage. The firechief immediately ordered the evacuation of area residents. The evacuation decision, was made within 10 minutes after the derailment. The firechief was also concerned about a possible explosion of the gas and contamination of the Village Sewage Treatment Plant by chemical run-off.

At 4:30 a.m., a railroad dispatcher alerted DU-COMM to the wreck. The train crewmembers were not asked for, nor did they offer, any advice or instruction about the emergency handling of the tank car. They had not been trained to do so.

An area resident provided the earliest technical assistance to the firechief about 30 minutes following the derailment. The resident was a chemist and described the properties, danger, and probable behavior of the anhydrous ammonia to the firechief.

At 4:55 a.m., the first CNW representative reached the site. Sixteen minutes later, another official of the CNW arrived and discussed the emergency with the firechief. The official advised the use of water on the leaking ammonia.

Shortly after he detected the ammonia odor, the firechief requested that the Manufacturing Chemists Association's Transportation Emergency Center (CHEMTREC) be contacted. He expected CHEMTREC to send someone to the scene to help him with the emergency. However, because he transmitted his request via a portable radio with insufficient range, his request was not received by DU-COMM. CHEMTREC was not notified until 6:26 a.m. when an Illinois Environmental Protection Agency (EPA) representative called CHEMTREC for advice. The EPA representative relayed the CHEMTREC advice to the Glen Ellyn police department at 6:45 a.m. CHEMTREC's advice to the EPA representative was taken from the MCA CHEM-CARD, CC-44. (See appendix B.)

A representative of Phillips Petroleum Company (Phillips), the shipper of the ammonia, also went to the accident site. Phillips' policy is to provide emergency assistance to the railroad if requested.

About 9 a.m., the firechief began using water to reduce the quantity of ammonia vapors that were being dispersed in the area. Shortly thereafter, the tank car was approached to determine the size of the puncture. Because of the way the vapor cloud was formed as ammonia escaped through the crack, observers thought the puncture was a large one; they had concluded that the tank would be empty in 1 to 1 1/2 hours. Examination showed the puncture was only 1/8 inch by 3 inches.

During the afternoon, arrangements were made to transfer the remaining contents of the leaking tank car into two ammonia tank vehicles. The transfer was delayed until the assistant firechief and a consultant of the CNW sealed the puncture; they then pumped off the remaining ammonia from the leaking tank car. The evacuees were permitted to return to their homes about 9:00 p.m.

About 6:30 a.m., on May 17, Lake Ellyn and a storm water reservoir were reported to be contaminated by oil and ammonia from the water runoff from the accident site. The contamination also killed fish in Lake Ellyn.

ANALYSIS

Because the main line tracks in the vicinity of the accident were supposedly maintained to the Federal Track Safety Standards for Class 4 track, the allowable maximum speeds were 60 mph for freight trains and 80 mph for passenger trains. The CNW, however, had set maximum speeds of 40 mph for most freight trains and 60 mph for passenger trains. The CNW had recently issued new instructions that allowed freight trains that met certain specifications to be operated in the area at 60 mph. Even though carriers may set speed limits lower than those allowed by the FRA, the track must still be maintained to the FRA requirements for each track class.

Train No. 242 was the first eastbound train to qualify for the higher speed since instructions had been issued; a speed of 60 mph was authorized by train order. Crewmembers estimated the speed of No. 242 to be about 60 mph as it entered the curve. The crewmembers on the locomotive stated that immediately before the derailment, the locomotive lunged toward the north side and then toward the south side. Before this movement the locomotive was reported to have been riding well with no unusual lateral movements. The train had traveled a considerable distance without difficulty and had rounded curves of equal or even sharper degree without lunging. Unless there was a mechanical failure of the locomotive as the train approached the point of the accident, it must be assumed that the locomotive was producing generally the same forces in relation to track conditions as it was before the accident. Inspections of the locomotive after the accident disclosed no defective conditions which would have caused the lateral movements. Therefore, it is assumed that track conditions produced the excessive lateral movements felt by the crewmembers.

The increased speed of No. 242 from 40 to 60 mph was a factor in producing sufficient lateral force to cause the north rail of track 2 to overturn. All eastbound freight trains before No. 242 had operated over this track at speeds of 40 mph or less. Six-wheel-truck locomotives produce considerable lateral forces as they move around curves. Increasing the speed to 60 mph over undesirable track conditions produced more lateral force than the track could support

The engineer of No. 380 did not have enough time between the derailment of No. 242 and the collision of his train with the derailed equipment to stop his train short of the collision. The fact that he was notified at all indicates that the engineer of No. 242 was alert.

The elevated north rail of track 2 appeared to have overturned under the fourth locomotive unit, approximately 1,500 feet east of the beginning of the 1°54' portion of the compound curve. Although the FRA permits 3 inches less superelevation than that required for equilibrium speeds, this difference should not create lateral forces great enough to overturn the elevated rail of the curve if the rail is adequately secured to nondefective ties. From the inspection of the track west of the derailment, it was evident that the crosstie conditions under various joints were inadequate to meet Federal Track Safety Standards for Class 4 track. The existing superelevation of 4.9 inches compared favorably with the required 4.8 inches.

Uniformity in the track curvature and superelevation is assumed in preparing criteria for the maximum allowable operating speed. Although track measurements for alignment, gage, and cross level taken at the accident site were within the limits allowed by the Federal Track Safety Standards, the curvature and superelevation varied considerably. From these imperfect track conditions, additional lateral and vertical forces are created as the wheels strike the uneven points in the alignment of

the curve and as the wheels ride the surface irregularities of the track. All of the induced lateral and vertical forces must be absorbed by the track structure which supports the train. Any structural deficiency in the track will become evident as it is exposed to the abnormal stress.

Trains moving at speeds of 40 mph or less around curves that have deficiencies such as those described in this case may not generate sufficient forces to cause the outside rail to overturn; but when the speed is increased to 60 mph, these forces are greatly increased.

The condition of track 2 east from the point of the derailment could not be determined because the track was destroyed by the derailment. However, it may be assumed that conditions similar to those found west of the derailment point existed in the destroyed area. The reported riding conditions of the locomotive further supports the assumption that defective conditions existed.

The postaccident examination of track 2 revealed additional conditions --crosstie defects--that would have permitted freight trains to be operated at speeds no higher than 40 mph according to FRA regulations.

This accident shows how hazardous materials can complicate the safe handling of a train emergency. Awareness of the presence of hazardous materials in a train wreck during the earliest stage of the emergency response is essential for policemen and diremen. When hazardous materials are present, firemen may have to abandon their traditional "attack and extinguish" approaches and adopt alternative emergency handling methods.

Federal regulations require that hazardous materials cars be placarded and that commodity names be stenciled on cars carrying certain commodities. The traincrew must carry documents that indicate the position in the train of each car containing hazardous materials. A member of the traincrew also must possess a copy of the shipping papers for the hazardous materials which shows the information required by 49 CFR 172.202 and 172.203. Although emergency personnel are expected to remember to look for the placards, stencils, or crewman with the hazardous materials information, in this case it was not necessary because the firechief immediately recognized the odor of ammonia. The odor of the ammonia was the first indication of hazardous materials given to emergency personnel. These circumstances suggest that current methods should not be relied on to alert emergency personnel to the presence of hazardous materials in train accidents. Public safety officials need a reliable procedure to notify them of the presence of hazardous materials in train accidents so that they can adjust their emergency response to accommodate the special handling that may be required during the critical first few minutes of the emergency. A procedure for linking hazardous materials emergency diagnosis and response experts to onscene public safety officials at railroad hazardous materials emergencies would be more responsive to the immediate decisionmaking needs of these officials than existing procedures, which are based on manuals, training, or computer readouts.

Communications between the DU-COMM communicator and the railroad dispatcher within 3 minutes after the Glen Ellyn derailment suggest a way to meet the need for prompt notification. The railroad dispatcher should know the current status of trains that are carrying hazardous materials and which might be involved in an accident. The dispatcher could be required to communicate this information to the public safety communicator as soon as he becomes aware of a wreck involving such a train. If the dispatcher were provided with the names and locations of the hazardous materials in the train, he could provide this information to the public safety communicator also. The communicator could relay this information to the emergency personnel. At Glen Ellyn, if the dispatcher had known of the anhydrous ammonia shipment at the time of his call to DU-COMM, the firechief could have been alerted before he arrived at the scene.

After emergency personnel have been alerted to the presence of hazardous materials, they must have technical advice on how to eliminate the hazard. The firechief's discussion with the local chemist during the early stage of the emergency showed his need for technical assistance. Based on his training, the firechief did not attack the fire in No. 242's 15th car until he and the local chemist had considered the threat of the ammonia leaking from No. 380's fifth car, and the safety or environmental consequences that could occur from the fire department's actions. Uncertainties about these consequences delayed a response; this prolonged the evacuation. These circumstances question the validity and reliability of current methods of providing emergency assistance to local public safety officials.

There is presently no group of experts, such as the "hazardous materials squad" planned by the Glen Ellyn firechief, available to emergency personnel. CHEMTREC is designed to verbally convey information from written data sources to onscene officials. It can contact experts in member companies who are asked to communicate with the onscene emergency officials. However, the CHEMTREC communications system is not designed in a way that facilitates direct contact between the onscene officials and the expert.

The Safety Board recognizes that the establishment of a "hazardous materials squad" to provide nationwide service in railroad hazardous materials accidents requires study. The availability of competent experts, the establishment of lines of communication between public safety communicators and these experts, the source of funds, liability of advice provided, and methods for evaluating the continuing need for the service are some of the areas that need to be examined. The effects of present regulations and the development of improved emergency response methods, the relationship of such a group to other emergency disaster programs, and reduced training demands also require study before such a program can be recommended.

CHEMTREC's operational experience seems to provide the most comprehensive basis for evaluating a "hazardous materials squad" procedure for train accidents. CHEMTREC is supported by shippers who introduce many hazardous materials into rail transportation and it has worked closely with other organizations that offer emergency assistance. Therefore, it would be uniquely qualified to provide such an evaluation.

CONCLUSIONS

Findings

1. Train No. 242 was operating in accordance with the rules of the carrier as it approached the derailment point.

2. The increased speed of No. 242 from 40 to 60 mph produced greater forces against the outer rail of the curve than the forces produced by other trains that operated on the curve at 40 mph or less.

3. The engineer of No. 242 promptly warned the crew of No. 380 of the derailment.

4. The engineer of No. 380 did not have enough time between the derailment of No. 242 and the collision of his train with the derailed equipment to reduce substantially the speed of his train.

5. The examination of track 2 revealed several defective conditions which made the track ineligible for its designation by the FRA as a Class 4 track.

6. The reported lunging of No. 242's locomotive as the derailment occurred was caused by track conditions.

7. The defective crosstie conditions at joints contributed to the track defects which generated the high lateral forces produced by the locomotive as it moved around the compound curve.

8. If the tank car that contained the anhydrous ammonia had been provided with head shields, the tankhead would not have been punctured during the derailment.

9. Current methods of alerting public safety officials to the presence of hazardous materials at the scene of train accidents cannot be relied on to provide information in time to influence early response decisions.

10. Public safety officials need a reliable procedure to notify them of the presence of hazardous materials in train accidents so that they can adjust their emergency response to accommodate the special handling that may be required during the critical first few minutes of the emergency.

11. A procedure for linking hazardous materials emergency diagnosis and response experts to onscene public safety officials at railroad hazardous materials emergencies would be more responsive to the immediate decisionmaking needs of these officials than existing procedures, which are based on manuals, training, or computer readouts.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the overturning of the outside rail of a 1°54' to 2°15' compound curve because the rail was unable to withstand the lateral forces of the locomotive induced by the speed of the train on track which did not comply with Federal Track Safety Standards.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board made the following recommendations:

.....to the U.S. Department of Transportation:

"Require by regulation that persons performing train dispatching functions maintain a record of trains and cars that are carrying hazardous materials and of current methods of, and procedures for, containment of these materials in the event of a mishap and communicate this information to public safety officials immediately after they learn of a train accident. (Class II, Priority Followup) (R-77-9)

"Require the Chicago and North Western Transportation Company to maintain its tracks to the specifications of the Federal Track Standards for each class and not increase train speeds until it is determined that the track is adequate for such speeds." (Class II, Priority Followup) (R-77-10)

.....to the Chicago and North Western Transportation Company:

"Maintain tracks to the specifications of the Federal Track Safety Standards for each class and do not increase train speeds until it is determined that the track is adquate for such speeds." (Class II, Priority Followup) (R-77-11)

.....to the Manufacturing Chemist Association:

"Analyze the operating experience of the CHEMTREC system and furnish the Materials Transportation Bureau of the U.S. Department of Transportation with recommendations for a system to link appropriate hazardous materials experts with onscene public safety officials during the critical first few minutes of a train accident involving hazardous materials." (Class II, Priority Followup) (R-77-12)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

WILLIAM R. HALEY, Member, did not participate in the adoption of this report.

March 31, 1977

APPENDIX A

TRACK MEASUREMENTS

May 20, 1976

Track Centers

Track #2

Track centers measurements were taken between track #2 and track #3 starting with mid-ordinates station #2 and going west.

Station	Track Centers
2.	14'-3"
3.	14'-4 1/4"
4.	14'-4 3/4"
5.	14'-4"
6.	14'-4"
7.	14'-4"
8.	14'-3 1/2"
9.	14'-3"
10.	14'-2 3/4"
11.	14'-3 1/2"
12.	14'-3 1/2"
13.	14'-3 1/2"
14.	14'-3/8"
15.	14'-4"
16.	14'-3 1/4"

May 19, 1976

MID-ORDINATES
Track #2

1. 1-15/16
2. 2
3. 1-5/8
4. 1-7/8
5. 1-7/8
6. 1-3/4
7. 1-1/2
8. 2-1/16
9. 1-7/8
10. 2
11. 1-3/4
12. 1-7/8
13. 1-7/8
14. 2-1/8
15. 1-1/2
16. 15/16
17. 2-3/4
18. 1-3/16
19. 2-1/4
20. 1-15/16
21. 2-1/4
    2-5/8 bad joint 6' west of station #21
22. 1-15/16
23. 2-1/4
24. 1-7/8
25. 2-1/2
26. 1-3/4
27. 2-1/2
28. 1-11/16
29. 2-1/8
30. 2-3/16
31. 1-7/8
32. 2-1/8
33. 1-5/16
34. 1-13/16
35. 1-7/8
36. 2-1/2
37. 1-1/2
38. 1-5/8
39. 2-1/16
40. 1-5/8
41. 1-15/16
42. 1-3/4
43. 1-7/8
44. 1-7/16
45. 1-1/2
46. 1-3/8
47. 1-1/16
48. 1
49. 5/8
50. 5/8
51. 7/16
52. 3/16
53. 0-0/0
54. 0-0/0

The above measurements were taken at 31-foot spacings using a 62-foot chord, starting at the west end of panels or 92'-6" west of the point of derailment.

(1)
May 17, 1976 (18 rails)
May 18, 1976 (22 rails)

CROSS LEVEL & GAGE CHECK
TRACK #2

The below cross level and gage measurements were taken at 19-1/2 foot spacings starting 112 feet west of the point of derailment on the north rail. This curve is a 2 degree, 11 minute with 4 1/2" full elevation.

39-ft rails	Elevation	Gage	
1/2.	4-7/8	56-15/16	
1.	5-1/16	56-7/8	
1 1/2.	5-1/4	57-1/8	
2.	5	57	
2 1/2.	5-1/2	56-7/8	
3.	5	57-1/16	
3 1/2.	4-7/8	57	
4.	5	57-1/4	
4 1/2.	4-3/4	57-1/4	
5.	4-7/8	56-15/16	
5 1/2.	4-7/8	57-1/8	
6.	5-1/8	57-5/16	
6 1/2.	5	57-3/16	
7.	5	57-3/16	
7 1/2.	4-7/8	57-1/8	
8.	5	57-1/16	
8 1/2.	4-3/4	57	
9.	5	57-1/8	
9 1/2.	4-3/4	57	
10.	5-1/16	57-1/8	
10 1/2.	5	57-1/16	
11.	5-3/8	57-1/4	
11 1/4.	5-3/4		
11 1/2.	5-1/8	57-1/4	
12.	4-7/8	57-1/8	
12 1/2.	4-1/4	57-3/8	shims 3/4" joint low rail
1/4.	4	56-15/16	
13.	3-7/8	57-1/8	
13 1/2.	4-1/2	57-3/16	shims joint tie not spiked & one bad
14.	4-7/8	57-1/4	tie.
14 1/2.	5-3/8	57-3/8	
15.	5	57-1/4	
15 1/2.	4-7/8	57-1/16	
16.	4-3/4	57-5/16	(170" between non-defective ties).
16 1/2.	4-5/8	57	
17.	4-3/4	57	
17 1/2	4-7/8	56-3/4	
18.	5	57-1/16	
18 1/4.	5-1/2	57-1/16	(Joint on South rail two bad ties)

(2)

CROSS LEVEL & GAGE CHECK

39-ft. rail	Elevation	Gage	
18 1/2.	4-3/4	57-1/8	
19.	4-3/4	57	
19 1/2.	4-3/4	57-1/8	
20.	4-7/8	57	
20 1/2.	4-3/4	57-1/8	
21.	4-3/4	56-7/8	
21 1/2.	4-3/4	56-15/16	
22.	4-1/2	57	
22 1/2.	4-1/2	57-1/8	
23.	4-3/4	57	
23 1/2.	4-3/4	56-13/16	
24.	4-7/8	56-15/16	
24 1/2.	5-1/8	57	
25.	4-7/8	57	
25 1/2.	4-7/8	57	
26.	4-7/8	56-3/4	
26 1/2	5-1/8	56-15/16	
27.	5-1/8	57-1/16	
27 1/2	5	57-1/16	
28.	4-7/8	57-1/4	
28 1/2	4-5/8	56-15/16	(joint)
29.	5-3/8	56-11/16	(joint)
29 1/2	5-7/8	56-15/16	
30.	5	57	
30 1/2	5	56-3/4	
31.	5-1/8	56-15/16	
31 1/2.	4-7/8	56-15/16	
32.	4-7/8	56-7/8	
32 1/2	4-5/8	56-3/4	
33.	5	56-13/16	(Tag on tie full elevation)
33 1/2.	4-7/8	56-7/8	
34.	4-1/4	56-5/8	
34 1/2.	4	56-7/16	
35.	3-5/8	56-3/4	
35 1/2.	3	56-5/8	
36.	2-7/8	56-5/8	
36 1/2.	2-1/2	56-3/4	
37.	2-1/8	56-11/16	
37 1/2.	1-7/8	56-7/8	
38.	1-1/2	56-15/16	
38 1/2.	1	56-7/8	
39.	3/4	56-15/16	
39 1/2.	3/8	56-7/8	
40.	3/8	56-3/4	
40 1/2.	1/8	56-3/4	

May 20, 1976

CROSS LEVEL & GAGE UNDER LOAD
Track #2

The below cross level and gage measurements were taken under load at joints and intermediate points, using 19-1/2 ft. spacing starting 112 ft. west of the point of derailment.

39-ft. rail	Elevation	Gage
9 1/2.	4-3/4	57-1/16
12 1/2.	4	57-3/8 (shims 3/4" joint low rail)
1/4.	4	57-1/16
13 1/2.	4-3/4	57-3/16 (shims joint tie not spiked & one bad tie)
14 1/2.	5-3/8	57-11/16
16.	5	57-5/8 (joint had been repaired)
17.	4-3/4	57-1/8
18.	5-3/8	57-1/4
28 1/4.	4-3/4	57
28 1/2	4-5/8	56-11/16
29.	5-1/8	56-5/8
41.	0-0/0	56-13/16

APPENDIX B

Excerpts from MCA CHEM-CARD CC-44

ANHYDROUS AMMONIA

1.3 PHYSICAL FORM & APPEARANCE: Colorless liquefied compressed gas.

1.4 ODOR: Extremely pungent odor, typical ammonia odor

1.5 EFFECT WITH WATER: Liquid mixes with.

1.6 SHIPPING OR B/L DESCRIPTION: Anhydrous Ammonia - Nonflammable Compressed Gas

SHIPPER OR MANUFACTURER: SEE REVERSE

NATURE OF PRODUCT: Nonflammable compressed gas that has liquefied gas in the container. The gas is irritating and the liquid causes severe burns of skin or eyes.

FIRE: Can catch fire, but requires high ignition temperature

EXPOSURE: Exposure to liquid or high concentrations of vapor can cause severe burns. Excessive inhalation may cause severe damage to the lungs or even suffocation.

IN CASE OF ACCIDENT

SPILL OR LEAK Keep upwind from small leaks. Evacuate area downwind from large leaks or tank rupture and keep spectators at a safe distance. Approach spills and leaks from upwind. Shut off leak if without risk. Use gas mask with full-face mask and ammonia (Green) cannister (have refill cannisters available) around small leaks. Wear self-contained breathing apparatus around large leaks or spills. If necessary to enter spill area, wear protective clothing made of rubber or other materials impervious to ammonia, including boots and gloves. If possible prevent spilled or leaking liquid from entering waterways by diking or other means of containment. Water spray or fog is extremely effective in absorbing ammonia gas and should be used around leaks of gas only. Do not put water on liquid ammonia. Do not apply water to tank unless it is being heated by nearby fire.

FIRE Move containers promptly out of fire zone. If removal is impossible, cool containers with water spray.

Agricultural Grade Ammonia *
Refrigeration Grade Ammonia *
Commercial Grade Ammonia *
Metallurgical Grade Ammonia *
NH_3 *

EXPOSURE: Remove to fresh air and call a physician at once. If not breathing apply artificial respiration, oxygen. Do not use Pulmotors. If breathing is difficult, administer oxygen. In case of contact with liquid, immediately flush skin or eyes with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes at once. If clothing is frozen to skin thaw with water and remove. Keep patient at rest. Do not apply salves or ointments to skin or mucous membrane burns for at least 24 hours.

Contact below individual for additional information if the shipper cannot be found:

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Office - (713) -472-6141

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RAILROAD ACCIDENT REPORT

COLLISION OF TWO CONSOLIDATED RAILROAD CORPORATION COMMUTER TRAINS

NEW CANAAN, CONNECTICUT

JULY 13, 1976

REPORT NUMBER: NTSB-RAR-77-4

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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16. Abstract About 6:28 p.m., on July 13, 1976, Conrail commuter train No. 1994 collided with the rear of commuter train No. 1992 which was standing on the main track in New Canaan, Connecticut. The first car of No. 1994 and several cars of No. 1992 derailed. Two passengers were killed and 30 persons were injured.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 1994 to perceive the train ahead and to apply the brakes at the earliest possible time. Contributing to the accident was the excessive speed of the train as it passed the controlling signal at Cane and the inadequacy of the signal system to convey to the engineer the situation ahead and to insure compliance with the indications of the signals.

During the investigation of this accident, the National Transportation Safety Board issued two recommendations concerning the signal system to the Connecticut Department of Transportation and two recommendations jointly to the Connecticut Department of Transportation and the Metropolitan Transportation Authority concerning the operation of exit doors. A recommendation on eliminating unsafe conditions in the cars' interiors was reiterated and a recommendation to the FRA to promulgate regulations on the operation and construction of commuter cars was issued.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: May 19, 1977

COLLISION OF TWO CONSOLIDATED RAILROAD CORPORATION COMMUTER TRAINS NEW CANAAN, CONNECTICUT JULY 13, 1976

SYNOPSIS

About 6:28 p.m., on July 13, 1976, Conrail commuter train No. 1994 collided with the rear of commuter train No. 1992 which was standing on the main track in New Canaan, Connecticut. The first car of No. 1994 and several cars of No. 1992 derailed. Two passengers were killed and 30 persons were injured.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 1994 to perceive the train ahead and to apply the brakes at the earliest possible time. Contributing to the accident was the excessive speed of the train as it passed the controlling signal at Cane and the inadequacy of the signal system to convey to the engineer the situation ahead and to insure compliance with the indications of the signals.

INVESTIGATION

The Accident

At 5:09 p.m. on July 13, 1976, Consolidated Railroad Corporation (Conrail) commuter train No. 1992, consisting of six self-propelled cars manufactured by the General Electric Company and locally classified as "M-2," departed Grand Central Station in New York, New York, for New Canaan, Connecticut. The eastbound train arrived at New Canaan on time at 6:14 p.m. Passengers detrained through the two lead cars onto a high-level platform at the station. The train then backed to clear a switch which would permit it to enter a parallel track and thereby leave the station track clear for the arrival of commuter train No. 1994, which was due at 6:32 p.m. While backing, the engineer operated the train from the cab on the east end with direction from two crewmembers on the west end.

At 6:28 p.m., while standing on the main track with its rear car 315 feet east of the Richmond Hill Road crossing, the train was struck by No. 1994. (See figure 1.) The conductor had lined the switch for movement into the adjacent track and had returned to the front of the train. The crewmembers of No. 1992 neither saw No. 1994 approach nor heard its whistle for the Richmond Hill Road crossing.

Train No. 1994, which consisted of four M-2-type self-propelled cars, was assembled in Grand Central Station. The inspection of the train and tests of the brakes disclosed no defects. The train departed on time at 5:28 p.m. for New Canaan. After stopping at Stamford, Connecticut, the train entered the New Canaan Branch at 6:13 p.m. No exceptions were taken to the braking or operation of the train during stops on the branch. The last stop before the accident was Talmadge Hill, 2.2 miles west of New Canaan, where No. 1994's schedule departure time was 6:26 p.m.

Shortly after departing Talmadge Hill, No. 1994 passed signal 572E, which displayed an "approach" (yellow) aspect. After moving around a curve to the left, the train passed over a wheel flange lubricator and crossed Richmond Hill Road. The speed of No. 1994 was estimated by the engineer to be about 30 mph as it approached the road crossing.

The conductor of No. 1994 entered the operating cab to confer with the engineer after departing from Talmadge Hill. The conductor left the cab and started back into the train as it approached Richmond Hill Road crossing. Several passengers were standing in the front of the first car and were looking forward through the end door window.

The engineer of No. 1994 said that he started to blow the whistle for the road crossing as the train passed the whistle post. He also said that he applied the brakes to slow the train from 30 mph after passing the lubricator. He said that he felt the train's wheels slip and slide after the brake application and that he saw the speedometer fluctuate. He said that the speed of the train was as much as 20 mph when it passed the last eastbound signal at Cane, 0.3 mile west of New Canaan, but that this speed did not concern him because the aspect of the signal never changed from "restricting." The front of No. 1994 was about 25 feet east of the signal when the engineer first saw the rear of No. 1992, which was 241 feet away.

The engineer made an emergency application of the brakes with the controller handle, left the operating cab, called a warning to the passengers in the lead car, and ran toward the rear of the car. The trains collided at 6:28 p.m.

The New Canaan Branch is a 7.9-mile-long, single-track line from Stamford to New Canaan. The high-level platform, which only accommodates the first two cars of a train is located along the north side of the

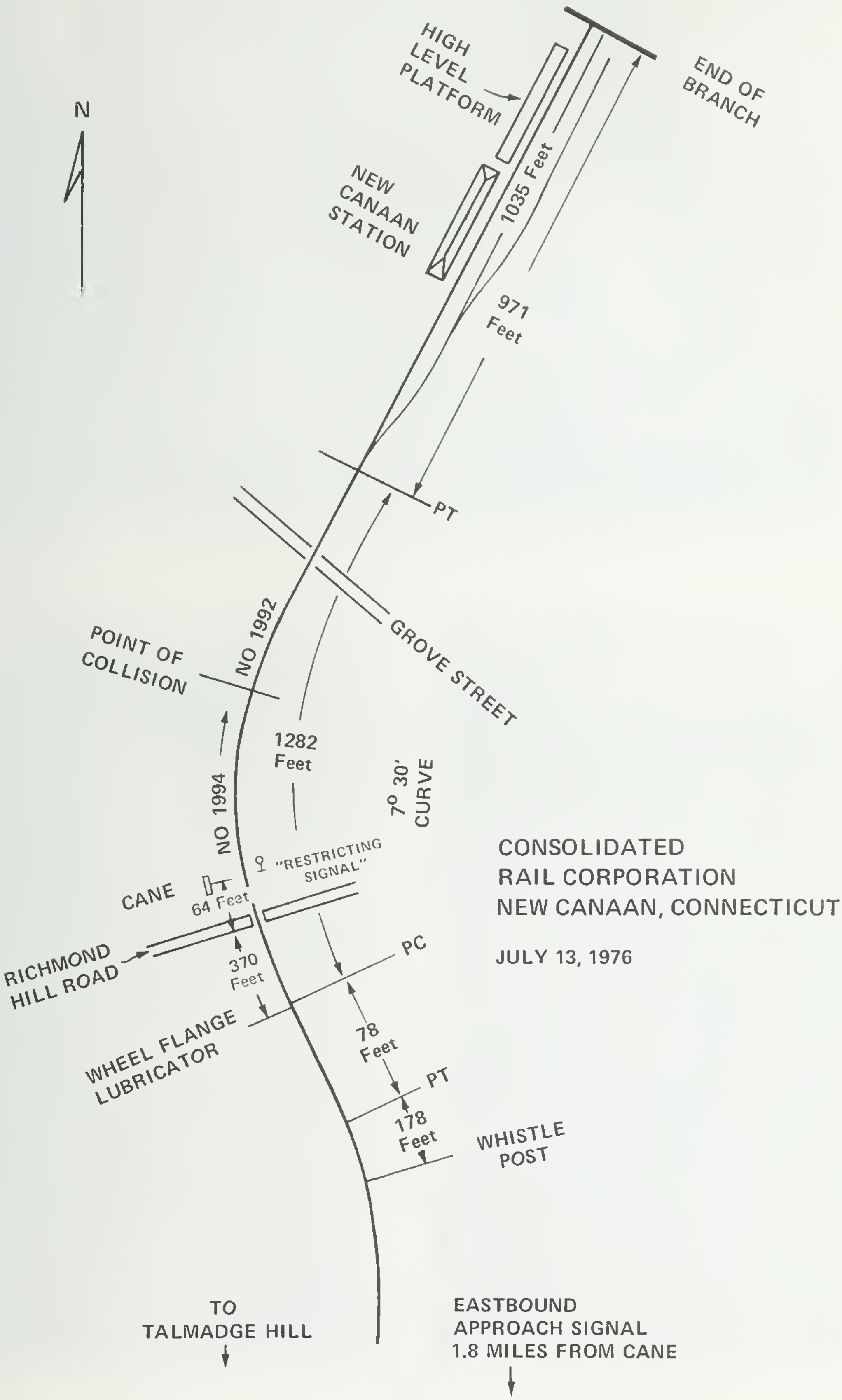

Figure 1. Plan of accident site.

station track at New Canaan. An auxiliary track, 1,035 feet long and parallel to the station track on the south, is used either to store trains or to permit trains to clear the station track.

An eastbound train approaching New Canaan moves around a curve to the left, then travels on 78 feet of straight track, and then enters a 7°30' curve to the right on which the accident occurred. Richmond Hill Road crosses the track 370 feet east of the beginning of the 7°30' curve, and Grove Street crosses the track 296 feet farther east. The grade for eastbound trains ascends slightly to the point of the collision. (See figure 1.)

Injuries to Persons

	Crewmembers	Passengers	Other
Fatal	0	2	0
Nonfatal	4	26	0
None	5	124	

Damage

The rear car of No. 1992 derailed and was extensively damaged. The collision posts were torn from the roof structural members and the end was pushed backward into the car at the roof. The center sills were buckled. The motorman's compartment on the left side was damaged but did not collapse. The end and side of the car at the right corner collapsed, but no passenger seats were destroyed. Roof panels in the interior at the damaged end were torn loose and hung down. (See figure 2.) The second car of No. 1992 derailed and four other cars were damaged.

The front end of the first car of No. 1994 collapsed rearward about 15 feet. The collision posts and the end framing were torn loose and driven back into the car. The end portion of the center sills were bent abruptly at the bolster upward and toward the left side. The sides of the car were spread. The collapsed area included the operator's compartmen and the first four seats on each side of the car. The batteries and some appliances attached to the underside of the floor were damaged. The car derailed. (See figure 3.) Several of the other cars of No. 1994 were slightly damaged.

About 40 feet of the track's north rail was turned over and crossties were damaged by the derailed cars. Damage to track and equipment was estimated to be $1,150,450.

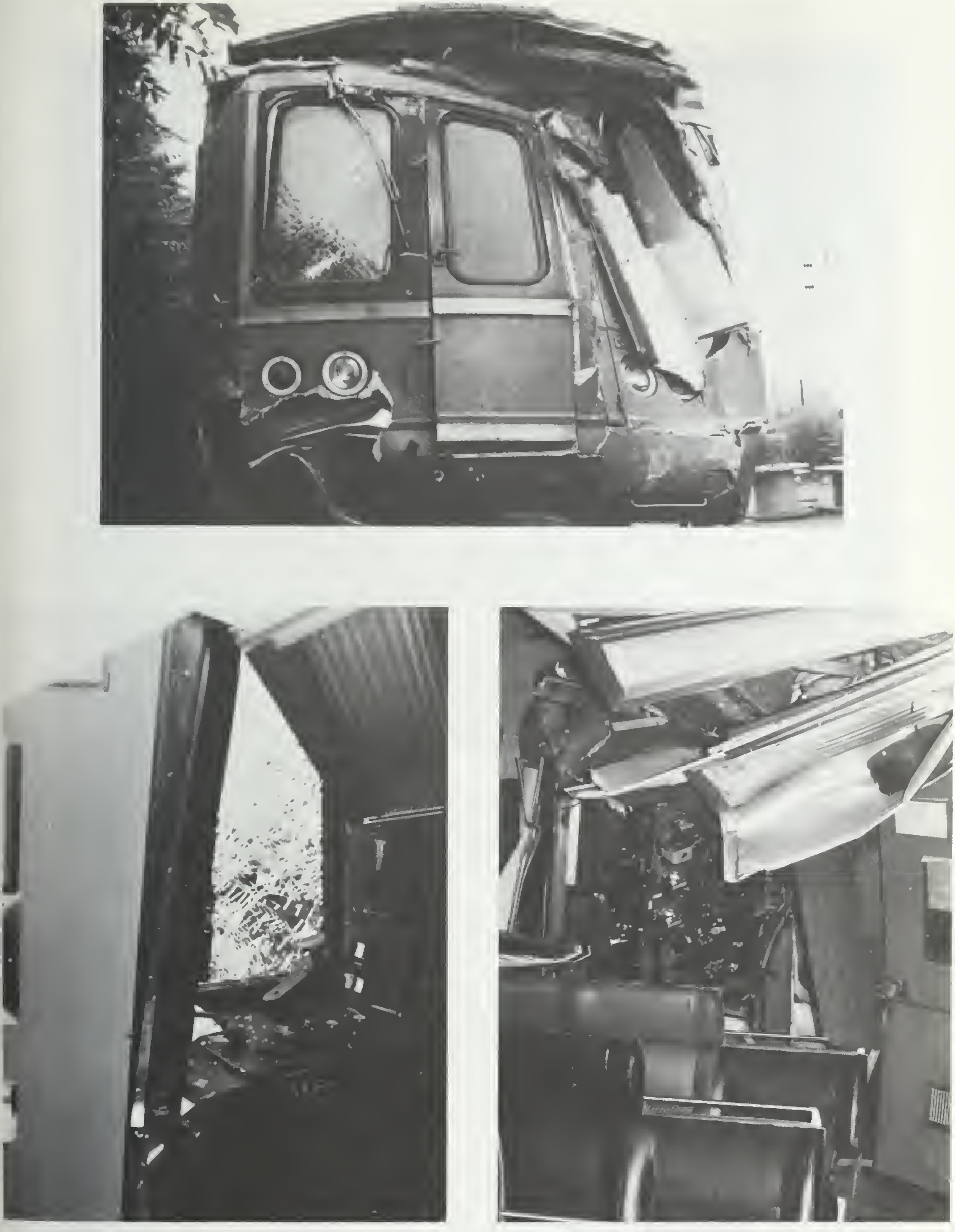

Figure 2. Damaged rear end of No. 1992 (top) interior view of cab (bottom left) interior view of rear of No. 1992 (bottom right).

Figure 3. Damaged lead car of train No. 1994.

Crew Information

The engineer of No. 1992 was not qualified to operate trains from Grand Central Station to New Canaan, so a qualified engineer was assigned to assist him. As No. 1992 backed to clear the switch leading to the side track, the assisting engineer was in the rear of the last car with the other two crewmembers. The assisting engineer neither heard No. 1994's whistle nor saw the approaching train until just before the collision.

The engineer of No. 1994 was hired in 1970 and was promoted to a locomotive engineer in March 1975. He only operated commuter trains between Grand Central Station and points in Connecticut. Most of this experience was with M-2-type cars. He never was assigned to a regular position and, therefore, worked only when his name was chosen from the "extra list." He said that during the preceding year he had operated trains on the New Canaan Branch about 10 times but that he had not operated No. 1994 for more than a year and that he never had operated No. 1992.

The engineer had attended the latest instruction classes on operating rules and he was current with the other required instruction courses. He was familiar with the operation of the braking systems on the M-2-type cars and he understood the operation of the slip-slide mechanism. When slipping or sliding did occur, he said that he operated his brakes to compensate for any loss of braking effectiveness.

His last physical examination, which was taken within the prescribed period, indicated that he was fit for duty.

Train Information

The cars in each train were self-propelled, electrically-operated commuter cars which are locally classified as "M-2." They had been purchased recently by the Metropolitan Transportation Authority (MTA) of New York and the Connecticut Department of Transportation (DOT) for operation between Grand Central Station and commuter stations in Connecticut. The M-2-type car is 85 feet long, is constructed of steel, and has four-wheel, motor-driven trucks; a pantograph on the roof collects power for the car's operation from an overhead catenary system.

An operator's compartment (cab) is on one end of each car. The cars are designed to be operated in pairs and each pair is semipermanently coupled on the ends opposite the operator's compartment. The couplers on the cab ends are fully automatic. Each car has dynamic and pneumatic braking systems which are automatically blended during normal brake operation.

Each car has an automatic slip-slide device. If wheels slip or slide, power or braking effort is automatically reduced until the wheels rotate properly. The device is not monitored by gauges in the operating cab, but the effect of its operation can be felt in the cab. Also, if the first pair of wheels slips or slides, the speedometer may fluctuate.

An emergency application of the brakes may be made by moving the controller handle to the emergency position or by the engineer removing his hand from the controller handle. An emergency application produced by either of these operations retains the slip-slide operation. An emergency button is also available for emergency braking but it bypasses the slip-slide device.

The cab end of each car is provided with two white headlights and two red marker lights. When pairs of cars are coupled for multiple-unit operations, the engineer controls all cars from the operator's compartment on one end of the train.

Each car has two doors on each side at quarter points, which can be operated individually or in conjunction with the side doors of other cars from a control point in the train. The side doors are operated electrically and must be locked in closed position before the train can proceed. If the car has electrical power, the doors can be opened from the outside with a key. If the car does not have power, each side door can be unlocked from inside the car by loosening the screws of a nearby cabinet door, opening the door, and operating a lever and switch as directed by instructions contained on the inside of the door. The cabinet, which is illuminated by an emergency light, contains wiring and electrical apparatus for the operation of the side doors. The screws in the cabinet door can be loosened by using a dime. Once unlocked, the side doors can be pushed opened. The doors cannot be opened from the outside if power is removed from the car. The end doors are manually operated.

The cars are designed for use at floor-level platforms and a wooden ladder is carried on each car for the emergency evacuation of passengers at other locations.

Each engineer's cab is provided with a radio for communications and an intercom system to make announcements throughout the train.

The M-2-type cars are very similar to the M-1-type cars described in Appendix C.

Method of Operation

Conrail operates the rail commuter service between Grand Central Station and stations in Connecticut under contract with the MTA and the Connecticut DOT.

Trains are operated on the New Canaan Branch between Stamford and Cane by signals of a traffic control system. The operator at Stamford controls the direction of movements. Once a train's direction of movement is established and the track is occupied, the direction of movement cannot be changed until the track is cleared. Trains are operated the 0.3 mile between Cane and New Canaan by the following rule from Conrail's "Rules for Conducting Transportation" (See Appendix B):

> 113. Movements on track other than main, secondary, running tracks and sidings may proceed at Restricted Speed unless otherwise specified in the timetable.

For operating purposes, the single track is designated a main track between Stamford and Cane and a station track between Cane and New Canaan.

The maximum authorized speed on the New Canaan Branch is 40 mph.

A wheel flange lubricator is located 434 feet west of Cane on the straight track between the curves. The oiler is preset to apply a certain amount of lubricant onto the gage side of the head of each rail when car wheels pass over a lever on the track. The resulting lubrication reduces wear between the car wheels and the rails in sharp curves.

Cane is designated by a nameboard, which is located along the north side of the main track. The last eastbound signal, located at Cane along the south side of the track, is a "dwarf," single-aspect signal which displays "restricting" (yellow) at all times. Trains are permitted to proceed past this signal but they must be prepared to stop short of a train, obstruction, improperly lined switch, or broken rail and they must not exceed 15 mph.

The eastbound approach signal is located 1.8 miles west of Cane. This signal can display two aspects for eastbound movements: "stop and proceed" when the block between this signal and Cane is occupied and "approach" at all other times. The "approach" indication permits a train to proceed but it must be prepared to stop at the next signal. Trains exceeding medium speed (30 mph) must reduce to that speed at once.

Survival Aspects

The passengers in the four cars of No. 1994 knew that they had to go forward into the first two cars to detrain because of the short length of the station platform at New Canaan. During the stop at Talmadge Hill, many persons changed cars via side doors and the platform because they found the cars' end doors difficult to operate. About 90 passengers were in the first car and about 60 passengers in the second car as No. 1994 approached New Canaan.

Passengers standing at the front of the first car saw the conductor enter the operating cab after the train departed Talmadge Hill. They saw him come out and head back into the train just before the accident. None of the passengers heard a whistle or felt any braking as the train approached Richmond Hill Road crossing, although they had heard the whistle at other times while the train was moving on the New Canaan Branch.

One passenger, who was looking out of the front window, stated that the train's speed appeared to be faster than usual but he could not estimate the speed. The passenger apparently saw No. 1992 on the track ahead before the engineer did, because he stated that he could not understand why it took the engineer so long to apply the brakes. He and other passengers near the front ran to the rear of the car as the engineer rushed out of the operating cab.

Two passengers who were seated in the first car's forward portion, which was destroyed on impact, were killed. One died instantly, and the other, who was trapped in the wreckage for several hours, died the next day. Twenty-six other passengers and four crewmembers were injured.

Many passengers were injured when thrown against the seats ahead or when thrown to the floor. Some persons were injured by parts of the seat they occupied or by bumping into other passengers. Several were injured by luggage and packages that fell from overhead racks.

Electrical power to No. 1994 was lost immediately when the catenary system shorted out and the cars' batteries were damaged. The side doors had to be opened manually by passengers using the emergency mechanisms inside the cabinets. The cars' emergency lights were inoperative.

One passenger reported that, after obtaining a dime and unlocking the cabinet door, he found the instructions mounted upsidedown. (See figure 4.) Another passenger reported that after opening another cabinet door, he was too nervous to follow the instructions.

After the side doors of No. 1994 were finally opened, the injured were promptly removed and cared for. A doctor, who was a passenger on the train, examined the injured and provided emergency treatment. His actions probably reduced the seriousness of many of the injuries. Emergency personnel from New Canaan and surrounding areas arrived at the accident site within minutes of the collision.

Tests and Research

Visibility and stopping distance tests were performed following the accident using identical equipment as that involved in the collision. It was determined that the eastbound signal at Cane first became visible to the engineer of an eastbound train when the front of the train was 350

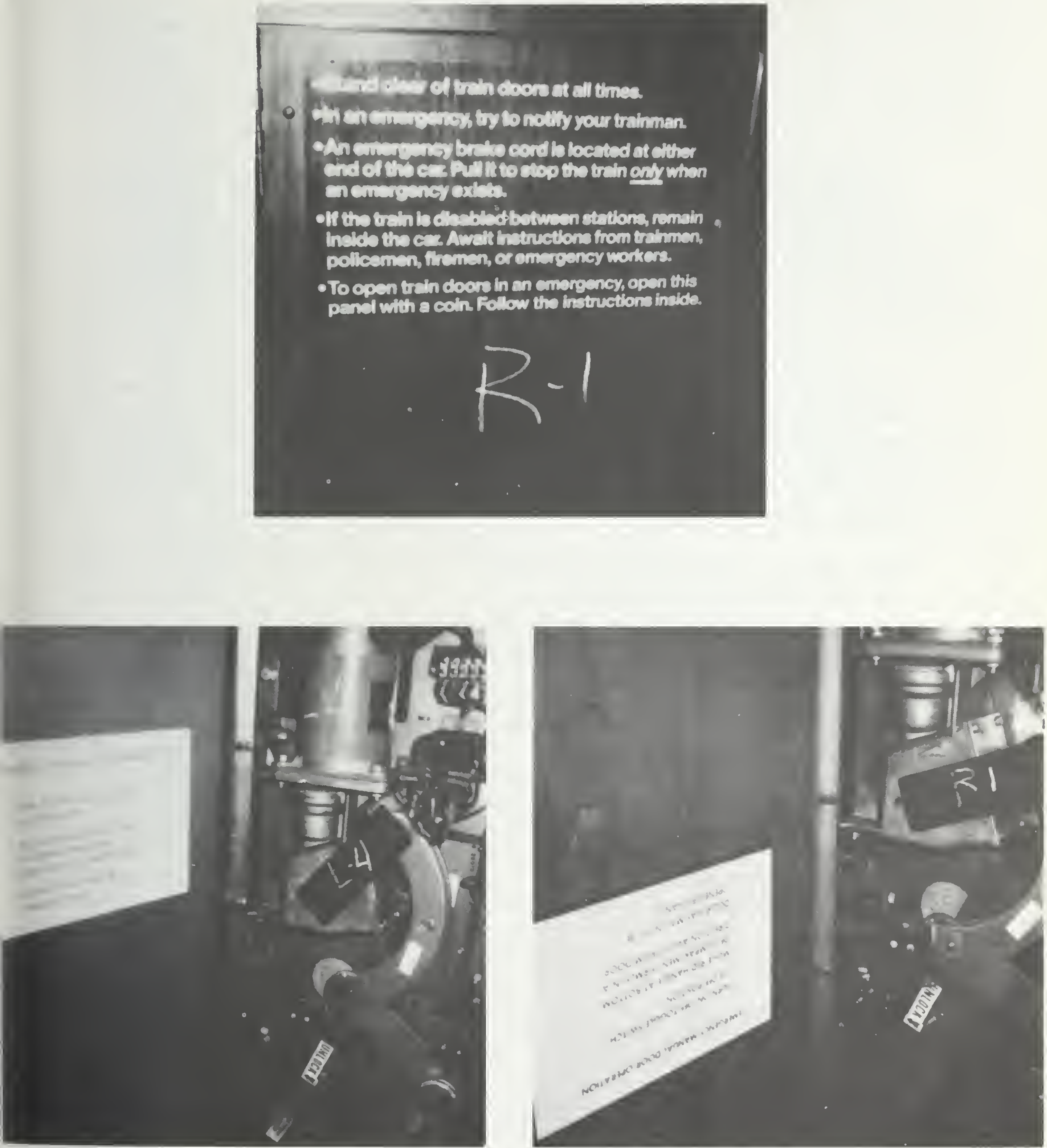

Figure 4. Emergency instructions on outside of compartment door containing manual door operation equipment (top) with instructions mounted properly (bottom, left) and mounted improperly (bottom, right).

feet west of the signal. The rear of a train standing at the same location as No. 1992 was at the time of the accident first became visible to the engineer of an approaching eastbound train when the front of the eastbound train was 356 feet west of the standing train or 90 feet west of the Cane signal. At that location there were no intervening structures or vegetation to obstruct the engineer's view of the standing train.

Stopping distance tests indicated that a similar train traveling at 15 mph could be stopped with a service brake application in about 94 feet, and at 30 mph in about 325 feet. A train traveling at 15 mph could be stopped with an emergency brake application made with the controller handle in 69 feet, and at 30 mph in 314 feet. An emergency brake application, made with the emergency button at a speed of 30 mph, stopped the train in 434 feet.

Inspection of the wheel flange lubricator indicated that it was out of adjustment and was supplying an excessive amount of lubricant. The stopping distance tests were performed with the lubricator operating as it had on the night of the accident. There were several slip-slide actuations in the immediate vicinity of the lubricator but none in the vicinity of the Cane signal.

Tests made of the braking systems on the cars in No. 1994 disclosed that they were working properly.

ANALYSIS

Train No. 1994 apparently departed from Talmadge Hill station before its scheduled time of 6:26 p.m. If the train were operated at a speed of 30 mph, which was permitted by the approach signal, it would have required 4 minutes to cover the 2 miles between Talmadge Hill and Cane where the accident occurred. Because the accident occurred at 6:28, No. 1994 must have departed Talmadge Hill at 6:24 or before. The train would have had to travel at 60 mph to reach the accident site if it had left Talmadge Hill at 6:26. It would have been virtually impossible to have operated the train at this speed because of the track's condition and alignment.

If No. 1994 had waited for its scheduled departure time at Talmadge Hill, No. 1992 might have had time to clear the station track at New Canaan and the accident would have been prevented. The crewmembers did not know what time No. 1994 departed from Talmadge Hill. The operating rules of the carrier do not require a train that is occupying the station track to clear the time of an approaching passenger train. The rules place the responsibility for safe operation on the approaching train.

If the engineer blew the proper whistle signal for the Richmond Hill Road crossing, as he claimed, it should have been heard either by the crewmembers on No. 1992, by passengers in No. 1994, or by other persons in the vicinity. None recalled hearing the whistle.

The engineer stated that he first saw No. 1992 on the track ahead when his train was about 25 feet east of the Cane signal. Tests indicated that the rear of No. 1992 became visible when No. 1994 was 90 feet west of the signal and 356 feet west of the standing train. The Board's investigation could not determine why the engineer of No. 1994 did not see No. 1992 in the first 115 feet that it was visible. Lighting was adequate and there were no obstructions intervening.

The stopping distance tests show that if No. 1994 had been operated at a speed of 20 mph as it passed the Cane signal, as the engineer, stated, and if the engineer had made an emergency brake application at the point where he claims to have first seen No. 1992, there would have been sufficient time and distance either to have stopped No. 1994 short of No. 1992 or to have reduced the speed of No. 1994 to the point where there would have been little impact on collision. Witnesses' statements and the extent of damage to the cars indicate that No. 1994 was moving in excess of 20 mph when it collided with No. 1992.

The flange lubricator was out of adjustment on the day of the accident and was supplying an excessive amount of lubricant. Any train passing over the device probably would have picked up lubricant on the treads of some wheels. This could have caused those wheels to slide if the brakes were applied before the lubricant had worn off. This sliding would have activated a train's automatic slip-slide device. No. 1994 was being operated at a speed which would have required that the brakes be applied near the oiler. If the engineer had not applied the brakes in the vicinity of the oiler, he had little or no chance of reducing the speed of the train in 434 feet to comply with the Cane signal's requirement of a speed of 15 mph or less.

Therefore, it must be assumed that the train's slip-slide control was actuated as it approached Richmond Hill Road crossing. However, from the tests made following the accident, the lubricant probably did not adversely affect the braking of the train as it passed the eastbound signal, especially if the brakes were applied throughout the entire distance. The engineer was thoroughly familiar with the operation of the slip-slide monitoring device and knew what was required to compensate for its actuation. If he noticed that the slip-slide device was operating after he passed over the oiler, he should have compensated for its operation as the train approached the Cane signal.

The eastbound signal at Cane, with its single aspect, did not convey information on conditions ahead. No. 1994's engineer stated that this was his reason for a lack of concern that the speed of the train, as it passed the signal, was somewhat higher than that permitted. The signal marked the end of the automatic signal territory and was not intended to convey any information to the engineer of conditions ahead.

A train standing at the New Canaan station cannot be seen by an approaching eastbound train until after the approaching train has passed the Cane signal and has moved some distance eastward around the curve. If the approaching train moves too far on the station track, it must stop and back up to permit the train in the station to back up and switch to the parallel track and thereby clear the station track for the approaching train. For both safety and efficient operation it would be advantageous to have the eastbound signal at Cane convey information on the occupancy of the station track.

The loss of electrical power meant that the side doors could not be operated from inside except by the manual unlocking system and that they could not be opened from the outside. To require passengers who have just experienced a train collision to use a dime to release four screw-type latches to open a cabinet door, and then to read emergency instructions without adequate lighting, and then to reach into a cabinet that is filled with wires and electrical equipment and operate a switch and lever so that a side door can be unlocked, is unreasonable.

The interiors of the cars involved in this accident are almost identical to those of the cars involved in an accident at MTA's Botanical Garden Station in New York City on January 2, 1975. 1/ Safety problems with the seats, the hand rail located on the seats, the overhead luggage racks, and other deficiencies are discussed in the Board's report of the Botanical Garden accident.

CONCLUSIONS

Findings

1. No. 1994 departed from Talmadge Hill before its scheduled departure time of 6:26 p.m.

2. The speed of No. 1994 as it passed the eastbound signal at Cane was greater than that permitted by the signal indication.

3. The brakes of No. 1994 were not applied as soon as the rear of No. 1992 could have been seen by the engineer.

1/ National Transportation Safety Board, Railroad Accident Report, "Collision of Two Penn Central Commuter Trains at Botanical Garden Station, New York City, January 2, 1975," NTSB-RAR-75-8.

4. There was sufficient distance to have stopped No. 1994 short of the rear of No. 1992 from the point where No. 1992 was first visible, and the line of sight from the engineer of No. 1994 to the rear of No. 1992 was unobstructed.

5. Lubricant from the flange lubricator may have caused slip-slide operation of the brakes in the vicinity of the oiler.

6. The lubricant probably had little or no effect on the stopping ability of No. 1994 as it passed the eastbound signal at Cane.

7. The engineer of No. 1994 did not sound the whistle for the crossing at Richmond Hill Road.

8. The speed of No. 1994 at the time of the collision exceeded 20 mph.

9. The two-car-length platform at New Canaan required that the passengers move forward into the first two cars to detrain. Because many passengers changed cars before the train arrived at New Canaan, about 150 persons were in the first two cars of No. 1994 at the time of the accident.

10. The passengers in the first car of No. 1994 had considerable difficulty opening the side doors of the car after the accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the engineer of train No. 1994 to perceive the train ahead and to apply the brakes in the earliest possible time. Contributing to the accident was the excessive speed of the train as it passed the controlling signal at Cane and the inadequacy of the signal system to convey to the engineer the situation ahead and to insure compliance with the indications of the signals.

RECOMMENDATIONS

As a result of this accident, the National Transportation Safety Board recommended, on July 28, 1976, that the Connecticut Department of Transportation require the Consolidated Railroad Corporation to:

> "Extend the automatic-block signal system to the end of the track at New Canaan so that the last signal will require the engineer to stop when that portion of the track is occupied. (R-76-46) (Class I, Urgent Followup)
>
> "Establish procedures until such signal protection can be provided to require that the engineer of each train approaching the New Canaan station be notified of the occupancy of

the track between the last signal and the station and be authorized to pass the last signal, based upon that condition. (R-76-47)(Class I, Urgent Followup)"

The Safety Board also recommended, on August 20, 1976, that the Connecticut Department of Transportation and the Metropolitan Transportation Authority:

"Change the emergency release mechanism for the side doors on the type of cars involved in this accident (M-1 and M-2) so that the doors can be opened easily by passengers under emergency conditions without opening the mechanism's compartment. (R-76-48) (Class I, Urgent Followup)

"Provide means for emergency aid personnel to open the doors from the outside when electrical power is lost. (R-76-49)(Class I, Urgent Followup)"

The Connecticut Department of Transportation has advised the Safety Board that, following the issuance of these interim recommendations made during the Board's investigation and from the State's participation in the investigation, it has taken the following corrective action:

°The eastbound signal at Cane has been changed to display a "Stop-and-Proceed" aspect. The signalling of the track between Cane and New Canaan Station is still under consideration.

°An emergency release mechanism that can be operated easily from either inside or outside is being designed for the side doors of M-1 and M-2-type cars.

°Arrangements are being made to change the hazard-producing features in the cars' interiors.

°Fire and rescue personnel along commuter train routes are being trained in the operation of these cars.

°The pressure on the end doors of the M-2-type cars has been reduced for easier operation of the doors.

°Emergency exit ladders are being installed beneath the cars.

As a result of this investigation the Safety Board also recommended that the Federal Railroad Administration:

"Promulgate regulations for railroad commuter lines that will:

Establish standards for the interior design of commuter cars to prevent and reduce injuries from accidents;

Insure that when the cars' power source fails, emergency lighting is adequate and doors can be operated easily from inside and outside;

Establish standards for the evacuation of passengers;

Prevent a passenger train from entering an occupied block. (Class II, Priority Followup)(R-77-13)"

The Safety Board also reiterates the following recommendation, which was made to the Metropolitan Transportation Authority following the investigation of the commuter train collision at Botanical Garden Station in New York City on January 2, 1975:

"Make such alterations to the interiors of the existing M-1 commuter cars as are necessary to correct the injury-producing features of the car design discussed in this report."

BY THE NATIONAL TRANSPORATION SAFETY BOARD.

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

May 19, 1977

APPENDIX A

INVESTIGATION

The accident described in this report was designated a major accident by the National Transportation Safety Board under the criteria established by the Safety Board's regulations.

This report is based on facts obtained from an investigation conducted by the Safety Board with assistance of other agencies. The Safety Board wishes to acknowledge the excellent cooperation extended by the following agencies during the investigation of this accident and in the taking of witnesses' statements at New Canaan, Connecticut, beginning on August 3, 1976:

Connecticut Department of Transportation

Connecticut Public Utilities Control Authority

Connecticut Public Transportation Authority

Federal Railroad Administration

Metropolitan Transportation Authority

Consolidated Railroad Corporation

General Electric Company

City of New Canaan

Brotherhood of Locomotive Engineers

United Transportation Union

APPENDIX B

Excerpts From Operating Rules of Consolidated Railroad Corporation

Signals

Fixed Signal—A signal of fixed location indicating a condition affecting the movement of a train or engine.

NOTE—The definition of a "Fixed Signal" covers such signals as switch target, train order, block, approach block limit, block limit, interlocking, speed signs, stop signs, yard limit signs, or other means for indicating a condition affecting the movement of a train or engine.

Aspect—The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching train; the appearance of a cab signal conveying an indication as viewed by an observer in the cab.

Indication—The information conveyed by the aspect of a signal.

Block Signal—A fixed signal, or hand signal in the absence of a fixed signal, at the entrance of a block to govern trains and engines in entering and using that block.

Block Limit Signal—A fixed signal indicating the limit of a block the use of which by trains or engines is prescribed by manual block signal system rules.

*****

Speeds

Normal Speed—The maximum authorized speed.

Limited Speed—Not exceeding 45 miles per hour.

Medium Speed—Not exceeding 30 miles per hour.

Reduced Speed—Prepared to stop short of train or obstruction.

Slow Speed—Not exceeding 15 miles per hour.

Restricted Speed—Proceed prepared to stop short of train, obstruction, or switch not properly lined looking out for broken rail, not exceeding 15 miles per hour.

NOTE—Speed applies to entire movement.

*****

14. Engine Whistle or Horn Signals

NOTE—The signals prescribed are illustrated by "o" for short sounds; "—" for long sounds. The sound of the whistle or horn should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

SOUND	INDICATION
(1) — — o —	(1) Approaching public crossings at grade, to be prolonged or repeated until crossing is reached unless otherwise provided.
	(1a) Whistle Signs
	W Rule 14(1) to be sounded at whistle sign.
	W MX Rule 14(1) to be sounded at whistle sign for multiple crossings and prolonged or repeated until last crossing is reached.
	W R Rule 14(1) not to be sounded except in an emergency.

NOTE—In sounding 14(1) the forward facing horn must be used. The rear facing horn will be used when forward facing horn is inoperative.

*****

92. A train must not leave a station in advance of its schedule leaving time.

NOTE—Where Rules 261 or 450 are in effect, or on two or more tracks where Rule 251 is in effect, a train may run in advance of its schedule time except at a station where it is scheduled to receive traffic and not otherwise specified in the timetable.

*****

113. Movements on tracks other than main, secondary, running tracks and sidings may proceed at Restricted Speed unless otherwise specified in the timetable.

*****

SIGNAL RULES

Rules Governing the Movement of Trains in the Same Direction by Block Signals

251. On portions of the railroad, and on designated tracks so specified in the timetable, trains will run with reference to other trains in the same direction by block signals whose indications will supersede the superiority of trains.

253. The Train Dispatcher must be advised in advance of any known condition that will delay the train or prevent it from making usual speed.

254. Except as affected by Rule 251 all Rules for Conducting Transportation remain in force.

Opposing and Following Movement of Trains by Block Signals

261. On portions of the railroad, and on designated tracks so specified in the timetable, trains will be governed by block signals whose indications will supersede the superiority of trains for both opposing and following movements on the same track.

*****

Rule 290

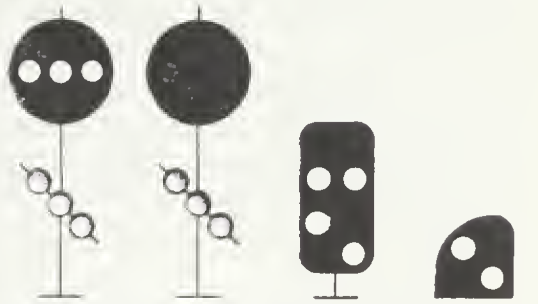

FIG. A FIG. AA FIG. A-1 FIG. A-2

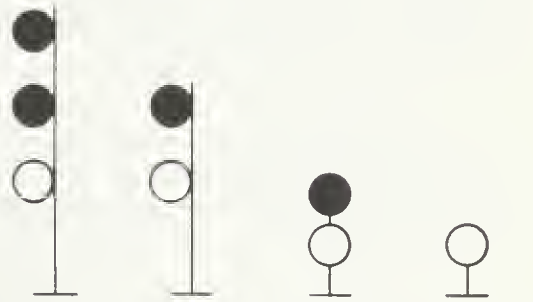

FIG. B FIG. B-1 FIG. B-2 FIG. B-3

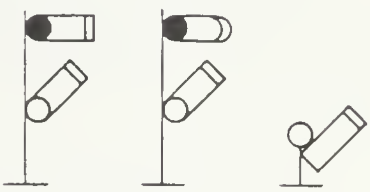

FIG. C FIG. C-1 FIG. C-2

IN CAB SIGNAL TERRITORY
CAB SIGNAL WILL DISPLAY

INDICATION—Proceed at Restricted speed.

NAME: Restricting.

APPENDIX C

DESCRIPTION OF THE INTERIOR OF AN M-1 COMMUTER CAR

Two doors are located on each side of a car. Each side door opening has double sliding doors which are operated electrically. The door openings are spaced to provide equal access to each quarter of the car. All side doors on one side of the train can be operated from a control station, which is actuated by a key. Individual doors can be operated from a switch mounted on an adjacent windscreen. The doors are locked when closed by the position of the mechanism's levers. Manual or emergency opening of the doors can be accomplished only by operating a release lever which is contained in unmarked cabinets near each door.

Windscreens are located on both sides of each door opening to protect passengers from wind when the doors are opened. Laminated glass panels at the top of the windscreen are being replaced with plastic panels. A metal frame is mounted on the glass or plastic panel to hold advertising posters.

Five-abreast seating with offset aisles is provided. The seats are permanently located so that passengers in the end quarters of the car face toward the center while those in the center quarters face the ends. In the center of the car two rows of seat are placed back-to-back.

All of the seats, with the exception of the aisle seat of the three-seat group, are classified as high-back seats. The tops of these seats are 24 inches above the seat cushion. The seats have formed plastic shells with upholstered cushions. The aisle seat has a low back with a top 19 inches above the seat cushion. A metal bar is secured to the top of the seat and extends the full width of the back. Standees use this bar as a handhold. The aisle seat's construction is similar to the highback seat.

A metal ticketholder is mounted on the top of the seat back for each group of seats.

A luggage rack with metal tubing is mounted on the wall above the windows along each side of the car. No restraints are provided to secure luggage or articles in the rack.

A fire extinguisher, emergency tools, and an emergency ladder are provided in each car.

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

UNION PACIFIC RAILROAD FREIGHT TRAIN DERAILMENT

HASTINGS, NEBRASKA

AUGUST 2, 1976

REPORT NUMBER: NTSB-RAR-77-1

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-RAR-77-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Railroad Accident Report: Union Pacific Railroad Freight Train Derailment Hastings, Nebraska, August 2, 1976		5. Report Date March 31, 1977
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10. Work Unit No. 2028
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Railroad Accident Report August 2, 1976
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

About 3:40 p.m., on August 2, 1976, 39 cars of Union Pacific Railroad freight train Extra 2800 East derailed near Hastings, Nebraska. Damage was estimated to be about $1,155,010. No one was injured.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the previously disturbed track structure to withstand the lateral forces generated by the 42nd, 43rd, and 44th cars of the train. The lateral forces resulted from a run-in of disproportionately heavy cars in the rear portion of the train.

17. Key Words	18. Distribution Statement
Slack action; brake pipe air reduction; train line; running release; initial reduction; crosstie renewal; torpedo; crib; destination blocking; weight blocking; rail temperature.	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	16	

NTSB Form 1765.2 (Rev. 9/74)

CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: March 31, 1977

UNION PACIFIC RAILROAD
FREIGHT TRAIN DERAILMENT
HASTINGS, NEBRASKA
AUGUST 2, 1976

SYNOPSIS

About 3:40 p.m., on August 2, 1976, 39 cars of Union Pacific Railroad freight train Extra 2800 East derailed near Hastings, Nebraska. Damage was estimated to be about $1,155,010. No one was injured.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the previously disturbed track structure to withstand the lateral forces generated by the 42nd, 43rd, and 44th cars of the train. The lateral forces resulted from a run-in of disproportionately heavy cars in the rear portion of the train.

INVESTIGATION

The Accident

The Union Pacific Railroad (UP) assembled freight train Extra 2800 East at its Bailey Yard in North Platte, Nebraska. The brakes were inspected before the train departed in compliance with the Federal Power Brake Law. No exceptions were taken to the brakes' condition. The front brakeman told the engineer of Extra 2800 East that the train had heavy cars on the rear.

The train departed Bailey Yard at 1:15 p.m., August 2, 1976, for Marysville, Kansas. It first stopped at Cozad, Nebraska, where the engineer initially reduced the brake pipe air pressure by 6 to 7 pounds. After allowing the brake pipe pressure to equalize, he made a further reduction to stop the train. As the train slowed to a stop, he gradually reduced the throttle to the idle position.

At Alfalfa Center, Nebraska, a trainmaster had placed two signal torpedoes 1/ on the rail to test the engineer's compliance with operating rules. The explosion of two torpedoes requires that an engineer immediately reduce his train's speed to 20 mph or less and to maintain that speed for 1 mile; if no restrictive situation is encountered, he may resume speed. When

1/ Small explosive charges used for signalling which, when fastened to a rail and overridden by a train, explode loudly.

Extra 2800 East struck the torpedoes, the engineer immediately made an initial brake pipe reduction of about 10 pounds. After the brake pipe pressure equalized, he further reduced the air pressure by 8 or 9 pounds. When the train's speed was reduced to about 10 mph, the engineer released the brakes and the train continued eastward at that speed. The engineer increased the train's speed after the 1-mile point. Neither the conductor nor the rear brakeman thought that the train was handled badly at Cozad or Alfalfa Center.

When the brakes were released, the trainmaster and a road foreman of engines observed slack action in the train about 75 to 80 cars from the engine. Neither man considered the slack action significant. The trainmaster took no exceptions to the manner in which the train was handled during the test.

The train approached the highway grade crossing 4.25 miles west of Hastings at a speed of 52 mph. The engineer saw persons on the track and earthmoving equipment near the north side of the track. He became alarmed and immediately made an 8- to 9-pound brake pipe reduction to prepare for an emergency application. He left the throttle in running position No. 7.

As the train approached closer to the crossing, the engineer thought that he saw someone wave a yellow flag, which he interpreted to be a warning signal. However, he made no further adjustment to the train brakes. Before the train reached the crossing, the engineer realized that a signal had not been given. One person did not get off of the track until the train was about 650 feet to 700 feet from the crossing. The engineer released the train brakes when he saw that the track was clear and when the locomotive was at the crossing. The train's speed had been reduced to about 45 mph. He reduced the throttle from position No. 7 to position No. 6 and immediately felt two surges of forward and backward motion in the train; this was immediately followed by an automatic emergency brake application from the train which was caused by the derailment. The engineer then released the locomotive brakes and closed the throttle.

Thirty-nine cars--the 42nd through the 81st--derailed immediately east of the crossing. No one was injured. Only the west trucks of the 42nd car derailed.

The track is straight from milepost 16.5 west of Hastings through the derailment area and is built on slight cuts and fills (See figure 1) The track is maintained to the Federal Railroad Administration (FRA) Class 5 track standard.

Beginning about milepost 5.25, west of Hastings, the track is on a 0.48 percent grade that descends to the east. Between milepost 4.5 and milepost 4.25 at the crossing, the grade changes to 0.0 percent (level) which continues east through the crossing. Approximately 1,200 feet east of the crossing, the grade descends 0.17 percent.

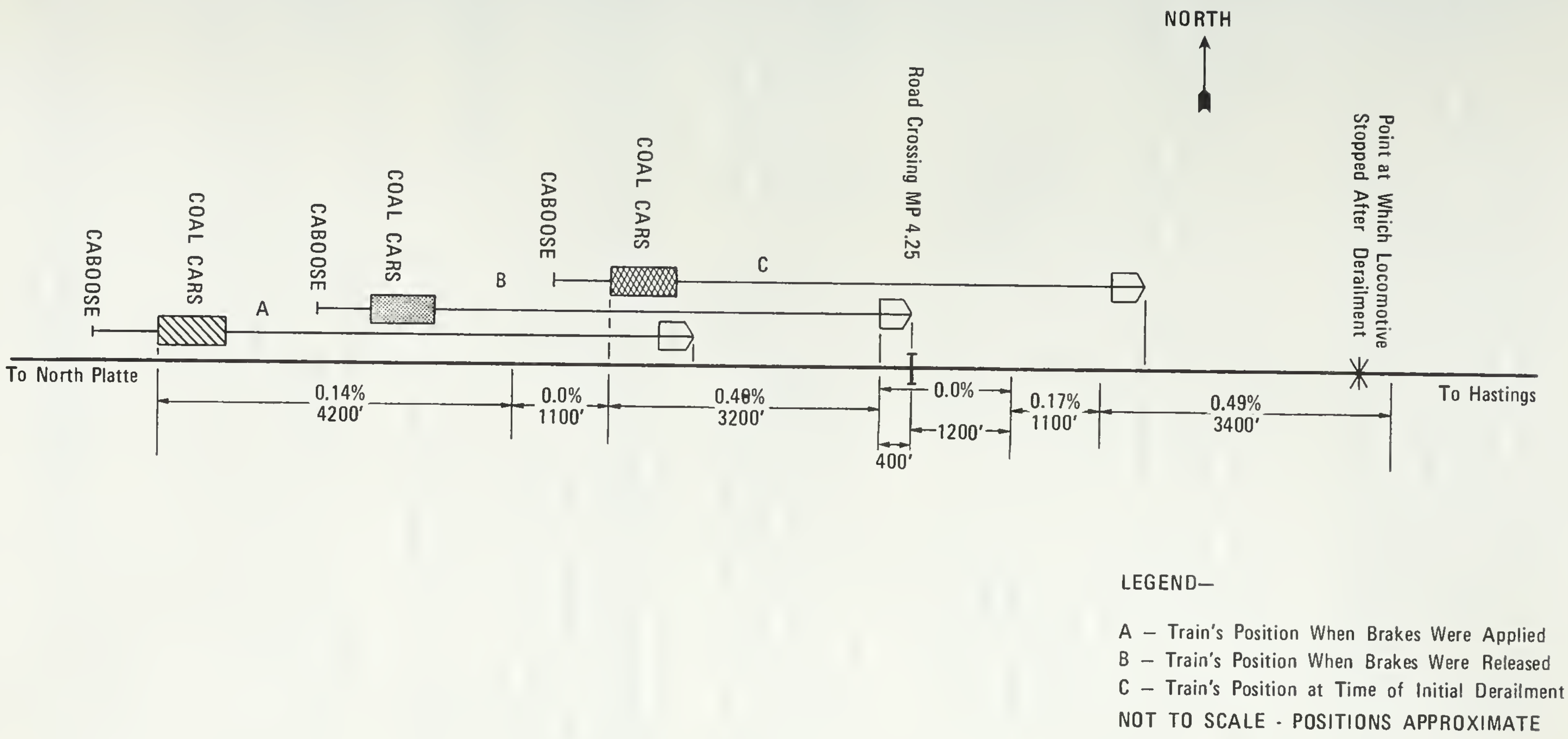

Figure 1. Plan of accident site.

The 133-pound continuous welded rails were set on 8-inch by 14-inch double-shoulder tie plates on 7-inch by 9-inch by 9-foot treated crossties. The rails were spiked with three lineholding spikes--one on the field side and two on the gage side--and one holddown spike on the gage side. The spiking pattern exceeded the requirements of the FRA Track Safety Standards. Channel-lock anchors were used to box every other crosstie.

Damage

Most of the 39 cars that derailed in the accident were heavily damaged. Track damage between milepost 4.3 and milepost 3.25 ranged from total destruction to damaged rails and crossties. The grade crossing was destroyed. Damage was estimated as follows:

Equipment	\$ 603,100
Track	83,046
Other Costs	468,864
Total Damage	\$1,155,010

Crewmember Information

The engineer of Extra 2800 East was employed as a fireman by the UP in August 1969. He was qualified on air brakes on April 22, 1973, and passed the operating rules examination for promotion to engineer on July 26, 1973. He was requalified on the operating rules on August 8, 1974, and he passed his last medical examination on January 1, 1975.

The engineer did not attend the UP training school for engineers at Cheyenne, Wyoming. Instead, he received on-the-job training under the supervision of "preferred" engineers 2/ supplemented by some classroom instruction. However, his supervisor, the road foreman of engines, had never supervised the engineer's operation of a train. The engineer attended rules and airbrake classes and received written information about operating procedures and the mechanical and electrical aspects of a locomotive. He was given written examinations covering airbrakes, machinery, and operating rules.

The airbrake instruction covered the use of dynamic brakes and how to prepare the train for braking. However, it did not give specific guidelines on when dynamic brakes should be used or for which braking technique to use when weight is unequally distributed in a train. The engineer said that he was advised to operate the train "very carefully" when heavily loaded cars were on the rear of the train.

Train Information

Extra 2800 East had three locomotive units. The lead unit, a General Electric model U-23-C with type 26-C airbrake system, was being

2/ Engineers of proven ability who were used as instructors for engineer trainees.

operated with its short end forward. The other two units were General Electric model U-30-C with type 26-L airbrake equipment. The lead unit and the caboose were equipped with operable radios which were used twice during the train's operation from North Platte to the accident site. They were not used immediately before the accident at the crossing. The lead unit also was equipped with a speed recorder.

The train's 71 loaded and 45 empty cars extended more than 1 mile. Its total weight was 8,240 tons. A block of 14 cars of coal, each weighing about 130 tons, was positioned in the rear portion of the train, 12 cars from the rear. About 70 percent of the total tonnage was contained in the rear 74 cars. Many of the cars on the forward portion of the train were either empty or lightly loaded.

The cars of Extra 2800 East were grouped at Bailey Yard according to their destination and to expedite subsequent handling; car distribution by weight was not considered. In most instances the grouping complied with a request from the receiving railroad. The only restraints to train make-up that are normally observed at Bailey Yard are rules that govern cars that require special handling, such as high and wide cars, cars of excessive weight, cars that carry certain commodities, or the adjacent positioning of short and long cars within the train.

Method of Operation

Trains are operated over the track in the area by a centralized traffic control (CTC) system. The maximum authorized train speed is 65 mph. There are no cab signals or automatic train control.

A company airbrake rule prohibits an engineer from making a running release of train brakes if the brakes are applied with a brake pipe pressure reduction of less than 10 pounds. This reduces the possibility of sticking brakes and the development of undesired slack action within the train.

Meteorological Information

The accident occurred in daylight, the weather was clear, and the maximum temperature that day was 75° F.

Tests and Research

The exact initial derailment point could not be determined because the track was destroyed.

An inspection of the first six derailed cars, the 42nd through the 47th, revealed that the couplers were intact. Marks that indicated side impact from lateral movement of the coupler on the end casting assembly were evident only on the first three derailed cars. It could not be

determined whether the impact marks were caused by couplers moving because of slack action or whether they were made as the cars were dragged down the roadbed after derailing. No marks that would have indicated dragging equipment before the accident were found west of the derailment area.

The speed recorder tape indicated the stop at Cozad, the speed reduction at Alfalfa Center, and the emergency stop at Hastings. It showed a speed decrease of 8 mph over a distance of 1 mile at Cozad, 9 mph over 1 mile at Alfalfa Center, and 7 to 8 mph over one-half mile at Hastings.

Other Information

The track workers arrived at the highway grade crossing about 8:30 a.m. to replace crossties and to raise the track through the crossing. The men wore yellow hard hats as part of their safety equipment. No slow order was issued or flag protection provided to protect the workers.

A UP instruction prohibits the replacement of more than three adjacent crossties at a time if the rail temperature is less than 100° F. (See appendix A.) The replacement of more than nine crossties in a 39-foot rail length is also prohibited. The instruction requires track workers to check the rail temperature before beginning work and requires the issuance of a slow order. However, the instruction does not apply to crosstie replacement through a highway grade crossing. (See appendix B.)

Another UP instruction prohibits raising the track more than 1 1/2 inches in one operation at any rail temperature. (See appendix C.) Track workers had raised the track in the crossing by 3 inches.

During the day, the ambient temperature reached a maximum of about 75° F. Track workers in the accident area usually assume that the rail temperature will be about 15° F higher than the ambient temperature thus making a working temperature of about 90° F. The rail thermometer provided to the section foreman for determining the actual rail temperature was not used on the day of the accident.

The track workers proceeded with the work by replacing two crossties at a time, completing work on each pair before replacing the next two. They replaced 14 crossties within the crossing and replaced 4 on the west end and 6 on the east end of the crossing. By 2:00 p.m., all 24 crossties were in place, the ballast had been replaced in the cribs, and the ends of the crossties were covered.

After 2:00 p.m., two freight trains--one eastbound and one westbound--passed over the crossing without incident. Neither train used its brakes at that point. About 3:40 p.m., when Extra 2800 East approached the crossi all work had been completed except for replacing and spiking the crossing boards.

The track workers witnessed the derailment but none could estimate the distance east of the crossing where the point of derailment was.

The section foreman had 2 1/2 years experience as a track worker, 1 1/2 years experience as a track force foreman, and 1 1/2 years experience as a section foreman. He received on-the-job training and had passed a written examination on general track structures and an oral examination on operating rules. His portable radio was tuned to the frequency that is used by main line freight trains, but he did not use it. Its use is not required during track work.

ANALYSIS

When a brake application is made by the engineer, the brakes apply on the cars in sequence from front to rear. This causes unbraked or less effectively braked trailing cars to close up on the forward cars where the brakes have already become effective. The individual braking of light cars is more effective than the braking of heavy cars. When brakes are first effectively applied, the initial retardation of light cars is greater than heavy cars. Add this effect to the normal run-in which results from sequential front to rear effective braking and it becomes apparent that blocks of heavy cars should not be placed behind light cars.

The arrangement of cars in Extra 2800 East concentrated slightly more than twice the tonnage in the trailing 74 cars than was in the lead 42 cars. When one considers that about 75 percent of those cars behind the first 42 cars, including the block of 14 130-ton cars of coal, were on the 0.48 percent descending grade when the engineer made the brake application, it is not unexpected to find evidence of undue lateral forces on the couplers of the 42nd, 43rd, and 44th cars. Considering these factors and the fact that the 42nd car's trailing truck was still on the rails after the accident, one can conclude that the compressive forces generated by the unequal braking of the light and heavy cars reached the highest magnitude in the 42nd, 43rd, and 44th cars.

The speed recorder tape indicated a deceleration rate in a half mile at Hastings which was about twice that previously developed at Cozad and at Alfalfa Center. This suggests that the brake pipe reduction to accomplish the reduction in speed at Hastings was considerably more than the 10-pound reduction reported by the engineer. This heavier braking on the descending grade increased the probability of a severe run-in by the heavily loaded cars in the rear of the train. The running release may have increased the slack action in the train.

Since the engineer had not been evaluated by his supervisor, the Safety Board cannot characterize his ability as an engineer. However, the lack of formal training at the carrier's school at Cheyenne, the absence of personal supervision of the engineer's performance by a road

foreman of engines, and his short experience raises the question of whether the engineer was capable of predicting the dynamic action of the train. Certainly a general admonition to "handle it carefully" and a brakeman's advice that the train had heavy cars on the rear were insufficient information to an engineer of this training and experience to prevent damaging slack action when braking this train.

Track workers violated a UP instruction when they raised the track in the crossing more than 1 1/2 inches on the day of the accident. Safety Board investigators found no information that indicated the height restriction on the raising of track through a grade crossing had been waived in this case. The foreman also failed to use a track thermometer as required by UP instruction to determine the exact temperature of the rails; it is not likely that this had any bearing on the accident, however.

Although investigators were not able to determine the exact location of the initial derailment, it was obvious that the first cars derailed immediately east of the crossing. Undoubtedly the track in the worked section was less stable and, thus, was less able to withstand the lateral forces imposed by a train during a heavy brake application. Therefore, the Safety Board believes that the disturbed track was a factor in the cause of the derailment. Given the arrangement of the cars in the train, the track profile, the inherent nature of forces generated by freight train braking, and the disturbed track in that location, it is predictable that the disturbed track would tend to fail under the dynamic forces exerte on it by the train.

Although not required by UP instruction a slow order might have prevented the accident because the engineer could have been prepared for the activity at the crossing. Such a precaution would also give more protecti to track and train personnel.

CONCLUSIONS

Findings

1. The engineer of Extra 2800 East knew that he was operating a long, heavy tonnage train and that much of the weight was located at the rear of the train.

2. The train was assembled at Bailey Yard without consideration for weight distribution.

3. The crewmembers did not notice any slack action or brake problems when the train stopped at Cozad or when the train's speed was substantially reduced at Alfalfa Center.

4. The trainmaster and a road foreman of engines saw slack action at Alfalfa Center, but did not report it.

5. The train's speed was reduced from 52 mph to 45 mph in approximately one-half mile as it approached the highway grade crossing at milepost 4.25.

6. The exact point of derailment could not be determined.

7. Analysis of the speed reduction recorded on the speed tape disclosed that the initial brake pipe air reduction made at Hastings was more than the 8- to 9-pound reduction that the engineer claimed he made. This indicated that the engineer did comply with the carrier's requirements for making a running release of brakes.

8. The slack generated in the train at milepost 4.25 was caused by a combination of automatic emergency brake operation, throttle reduction, track gradient, and weight distribution.

9. A Union Pacific instruction exempts highway grade crossings from restrictions that apply to crosstie replacement in other areas.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the previously disturbed track structure to withstand the lateral forces generated by the 42nd, 43rd, and 44th cars of the train. The lateral forces resulted from a run-in of disproportionately heavy cars in the rear portion of the train.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that the Federal Railroad Administration:

> "Promulgate regulations to insure that the locations of heavily loaded freight cars in a train will not adversely affect the train's operation. (Class II, Priority Followup) (R-77-3)
>
> "Require that trains operated over unstable track be limited by a slow order, verbal contact by radio, or by flag protection to speeds that will reduce the possibility of track buckling from forces that exceed the restraining ability of the track. (Class II, Priority Followup) (R-77-4)
>
> "Require that locomotive engineers be instructed in the braking of trains for varied circumstances that may develop during a train's operation." (Class II, Priority Followup) (R-77-5)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

WILLIAM R. HALEY, Member, did not participate.

March 31, 1977

APPENDIX A

INSTRUCTION BULLETIN CE-74-106-T

UNION PACIFIC RAILROAD COMPANY

Office of Chief Engineer

INSTRUCTION BULLETIN

NO. CE-74-106-T April 15, 1974

Sheet 1 of 2 Sheets

To: Track Department Supervisors and Foreman

SUBJECT: Tie Renewals in Track Containing Continuous Welded Rail

To the extent possible, renewal of ties shall be avoided in track containing continuous welded rail when rail temperatures exceed 100° F. Foremen supervising tie renewal operations in continuous welded rail territories must use rail thermometers to continuously monitor the rail temperature.

When tie replacements are being made, the surface and alignment of track shall be disturbed as little as possible and no more ballast shall be removed from the ends of the ties being replaced, or from the cribs between the ties, then is absolutely necessary. Supervisor or Foreman in charge of the work shall check rail conditions regularly to insure that tie replacements can be made without hazard of the track kicking out of surface or line. If there is evidence that the rail is extremely tight such as lifting up in the tie plates and straining against the spikes, or having the appearance of being extremely kinky and binding against the shoulders of the tie plates, etc., no tie replacement work shall be undertaken.

When rail temperature is 100° F or less, not more than three consecutive ties shall be replaced at a time, nor more than nine ties in any 39 foot length of track. During working hours while ties are being installed, train movements shall be restricted to a maximum of 40 mph speed over that portion of track where ties are to be installed during the day. If track conditions are satisfactory and rail temperature below 100° F at the end of the working day, this speed restriction shall be removed.

When rail temperatures are higher than 100° F, not more than two consecutive ties shall be replaced at a time, nor more than six ties in any 39 foot length of track. In addition, all train movements shall be restricted to a maximum of 40 mph speed during tie renewal operations and

INSTRUCTION BULLETIN

No. CE-74-106-T

Sheet 2 of 2 Sheets

for a period of 12 hours thereafter to consolidate and compact the disturbed ballast and thus assure a stable track condition at normal operating speeds.

Whenever the number of ties to be replaced exceed the limitations specified, this shall be accomplished by making two or more operations over the stretches of track involved, with a minimum lapse of time of 12 hours between consecutive operations over any segment of track.

Ties being removed and replaced must be flanked by good sound ties that are properly spiked, adequately anchored and firmly retained with sufficient ballast at the ends of the ties and in the cribs between the ties. All spikes must be fully drived, rail anchors applied, and full ballast section restored immediately as the new ties are installed.

/s/
R. M. BROWN
Chief Engineer

APPENDIX B

INSTRUCTION MESSAGE OF SEPTEMBER 12, 1974

NX5 HSJ1 0024 19:07 SEP 12 SKKS 0362 19:07

03 HASTINGS 12 1845

KCITY 3 JOW RSH WEW KANSAS CITY

(time stamp)
1974 SEP 12 PM 7 46

TOP LPP TOPEKA

MSVILLE 4 JOW HRB RLH PBA MARYSVILLE

OMAHA 2 HBD PBA OMAHA

HS01 2 WEW RLH HASTINGS

COPY HBD PBA OMAHA

MR. R. M. BROWN ADVISES THAT C. E. INSTRUCTION BULLETIN 74-106 WAS NOT INTENDED TO APPLY TO RENEWAL OF TIES IN ROAD CROSSINGS. NO SLOW ORDER IS REQUIRED WHEN RENEWING TIES IN ROAD CROSSING. EXTREME CAUTION SHOULD BE EXERCISED BY SECTION FOREMAN BY NOT REMOVING MORE THAN TWO TO THREE TIES AT ANY ONE TIME. THESE MUST BE FULLY SPIKED AND CRIBS FILLED IN AND TIES TAMPED BEFORE REMOVING ADDITIONAL TIES. IDEALLY EVERY THIRD TIE SHOULD BE REMOVED AND RENEWED THRU OUT THE CROSSING BEFORE STARTING THRU A SECOND TIME. THIS REQUIRES THREE PASSES THRU THE CROSSING TO RENEW ALL TIES IN THE CROSSING. ACKNOWLEDGE RECEIPT AND UNDERSTANDING.

WEW

APPENDIX C

INSTRUCTION BULLETIN CE-71-65-T

UNION PACIFIC RAILROAD COMPANY

Office of Chief Engineer

INSTRUCTION BULLETIN

No. CE-71-65-T May 21, 1971

Sheet 1 of 1

TO: Track Department Supervisors and Foremen

SUBJECT: Surfacing and Lining Continuous Welded Rail

Trackage containing continuous welded rail shall not be raised out-of-face until sufficient ballast has been uniformly distributed to assure having a full ballast section in accordance with CS-1 or CS-5 after the raise is made. In addition, rail anchors shall be adjusted to ensure full and proper bearing against ties to prevent rail movement.

If possible, out-of-face surfacing and lining in continuous welded rail territory should be avoided when rail temperatures exceed 90° F. When necessary to perform such work and rail temperatures are in excess of 90° F, the height of a single raise shall not exceed a maximum of 3/4 inch and all train movements shall be restricted to a maximum speed of 40 mph for a period of 48 hours after the track is raised to permit consolidation and compaction of the ballast and to assure track stability at normal train operating speeds.

The height of a single raise shall not exceed a maximum of 1-1/2 inches at any time, regardless of temperature. If a higher raise is required to meet the desired profile, additional raises shall be made with train traffic being operated over the track for a minimum of 24 hours between successive raises to fully compact the ballast.

/s/
R. M. BROWN
Chief Engineer

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RAILROAD ACCIDENT REPORT

REAR END COLLISION TO TWO GREATER CLEVELAND REGIONAL TRANSIT AUTHORITY TRAINS

CLEVELAND, OHIO
AUGUST 18, 1976

REPORT NUMBER: NTSB-RAR-77-5

UNITED STATES GOVERNMENT

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16. Abstract

About 11:35 a.m., on August 18, 1976, Greater Cleveland Regional Transit Authority train No. 461 struck the rear of train No. 409 which was standing near the East 79th Street Station in Cleveland, Ohio. Twenty persons were injured and property damage was estimated to be $61,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of train No. 461 to comply with the mandatory stop signal indication and to apply the brakes in emergency promptly after the train ahead had been sighted, and operation of the train at an excessive speed. Contributing to the probable cause was the lack of an effective operator training program and the ineffectiveness of the protective devices and procedures to prevent a following train from entering an occupied block.

As a result of its investigation of the accident, the National Transportation Safety Board made four recommendations to the Greater Cleveland Regional Transit Authority concerning the operation of the system, and one to the Federal Railroad Administration.

17. Key Words
Rapid transit, operator, cineston, fanning, automatic train stop, automatic train control, overspeed control, cab signals, train stop, trip stop, tripper, wayside signal, dynamic brakes, ATC bypass mode, pilot light, deadman control.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: August 4, 1977

REAR END COLLISION OF TWO GREATER CLEVELAND REGIONAL TRANSIT AUTHORITY TRAINS CLEVELAND, OHIO AUGUST 18, 1976

SYNOPSIS

About 11:35 a.m., on August 18, 1976, Greater Cleveland Regional Transit Authority train No. 461 struck the rear of train No. 409, which was standing near the East 79th Street Station in Cleveland, Ohio. Twenty persons were injured and property damage was estimated to be $61,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of train No. 461 to comply with the mandatory stop signal indication and to apply the brakes in emergency promptly after the train ahead had been sighted, and operation of the train at an excessive speed. Contributing to the probable cause was the lack of an effective operator training program and the ineffectiveness of the protective devices and procedures to prevent a following train from entering an occupied block.

INVESTIGATION

The Accident

Greater Cleveland Regional Transit Authority (RTA) train No. 409 departed RTA's eastern terminal, Windermere Station, about 11:25 a.m. on August 18, 1976. There were no known defects in the equipment. The train proceeded westward and made regularly scheduled stops at three consecutive stations. As it departed the University Circle Station, a pilot light in the operating compartment failed to illuminate, indicating a fault that caused the propulsion power to be interrupted. The car was allowed to coast down the grade without power to the East 105th Street Station.

In order to receive power, the operator depressed the pilot light bypass button with his left hand. He then operated the cineston control lever 1/ with his right hand and departed the station. As the train gained speed, he released the bypass button and transferred his left hand to the control lever. This would free his right hand so he could operate the radio to report his problem to RTA central control. During this movement, his left hand slipped from the cineston control and the car brakes automatically applied in emergency. The train stopped about 1,400 feet west of signal WE 220 and about 4,400 feet west of East 105th Street. (See figure 1.) While the air pressure was being restored to release the brakes, the train was struck from the rear by train No. 461.

Train No. 461, which was following No. 409, departed Windermere Station about 11:30 a.m. Before it left the terminal, there were no known equipment defects. As it moved from the station, the automatic train control (ATC) alarm sounded, which required the operator to stop the train. He asked an off-duty operator, who was a passenger, to come to the operating compartment and use her motor key to operate an ATC bypass control which would reset the equipment and minimize delay. The train proceeded to its next stop at Superior Station. The ATC alarm sounded again as the train departed this station. Once again the off-duty operator reset the ATC equipment and the train proceeded. Although the operating rules require it, the operator did not report the alarms or the operation of the ATC bypass control to RTA control because he said he intended to report them personally when he arrived at the main terminal.

The operator of No. 461 claimed that on his previous trip from Windermere, the brakes were not fully effective at Superior and University Circle Stations, which caused him to run past the station platforms. He did not notify anyone of this problem nor did he mention it to the off-duty operator, who had remained in the operating compartment.

About 1,300 feet east of the station platform at East 105th Street, No. 461 stopped at signal WE 263, which displayed a stop aspect. The operator saw No. 409 standing at the station platform ahead. After No. 409 left the station and the aspect of signal WE 263 changed to a clear indication, No. 461 moved into the station. After No. 461 left the station, it passed a signal displaying an "approach" aspect and then came to signal WE 232 which displayed a "stop" aspect. Signal WE 232 had the automatic train stop (ATS) trip arm in the raised position. The train moved past the signal and the ATS arm in accordance with company operating rules. The operator then applied full power and accelerated to about 30 mph. As No. 461 approached the next signal, WE 220, the operator saw that it also displayed a stop aspect, but he did not stop or reduce the train's speed.

1/ The cineston control lever is rotated in a horizontal plane to apply power or brakes or to allow coasting. The lever must be kept depressed while the train is moving; if released, the brakes automatically apply in emergency.

The operator gave conflicting testimony at this point. He said he thought the ATS would stop him at the signal. Then, he said he saw No. 409 ahead about 1,000 yards beyond the signal in one instance, and 50 or 60 feet in another, but he realized that it was stopped in the block of signal WE 220. Then he said that he began to brake as he passed signal WE 220 but that the brakes were not effective. He then began "fanning" 2/ the brakes and finally, about 60 or 70 feet from the standing train, he applied the brakes in emergency. The operator said that the emergency brake application was not effective. No. 461, while traveling about 25 mph, struck No. 409.

The accident occurred on the westbound main track about 1,600 feet east of the 79th Street Station. Signal WE 220 is about 1,400 feet east of the point of impact. The track is tangent for about 2,400 feet east of the accident site and the grade varies from 0.31 percent to 0.52 percent descending from the East 105th Street Station through the accident area. (See figure 1.)

Injuries to Persons

Injuries	Crewmembers	Passengers	Other
Fatal	0	0	0
Nonfatal	1	19	0
None	1	0	

Damage to Trains

The anticlimbers on each car prevented an override. One end of each car was damaged. The side doors on each car were not damaged and only a small amount of window glass was broken. (See figure 2.) There was no evidence of structural failures that would have contributed to the passengers' injuries.

Crew Information

The operator of No. 409 was employed as a bus operator by the predecessor of the RTA on September 1, 1964. He was required to serve 6 months as a bus operator before becoming eligible to be a rapid transit operator. He had worked as a rapid transit operator for 7 years.

His training as a rail operator consisted of 2 days of instruction by an RTA instructor and 3 days of train operation under the guidance of a qualified operator. He received training literature which showed the signal indications and explained their meanings. The operating and safety rules were given to him orally but he did not receive a book of the rules. He was also given a "troubleshooting" guide. After satisfactorily passing oral quizzes on signals and train operation, the RTA considered him to be a qualified operator.

2/ Repeatedly advancing and reversing the cineston lever to apply brakes, then backing off slightly but not far enough to release the brakes already applied.

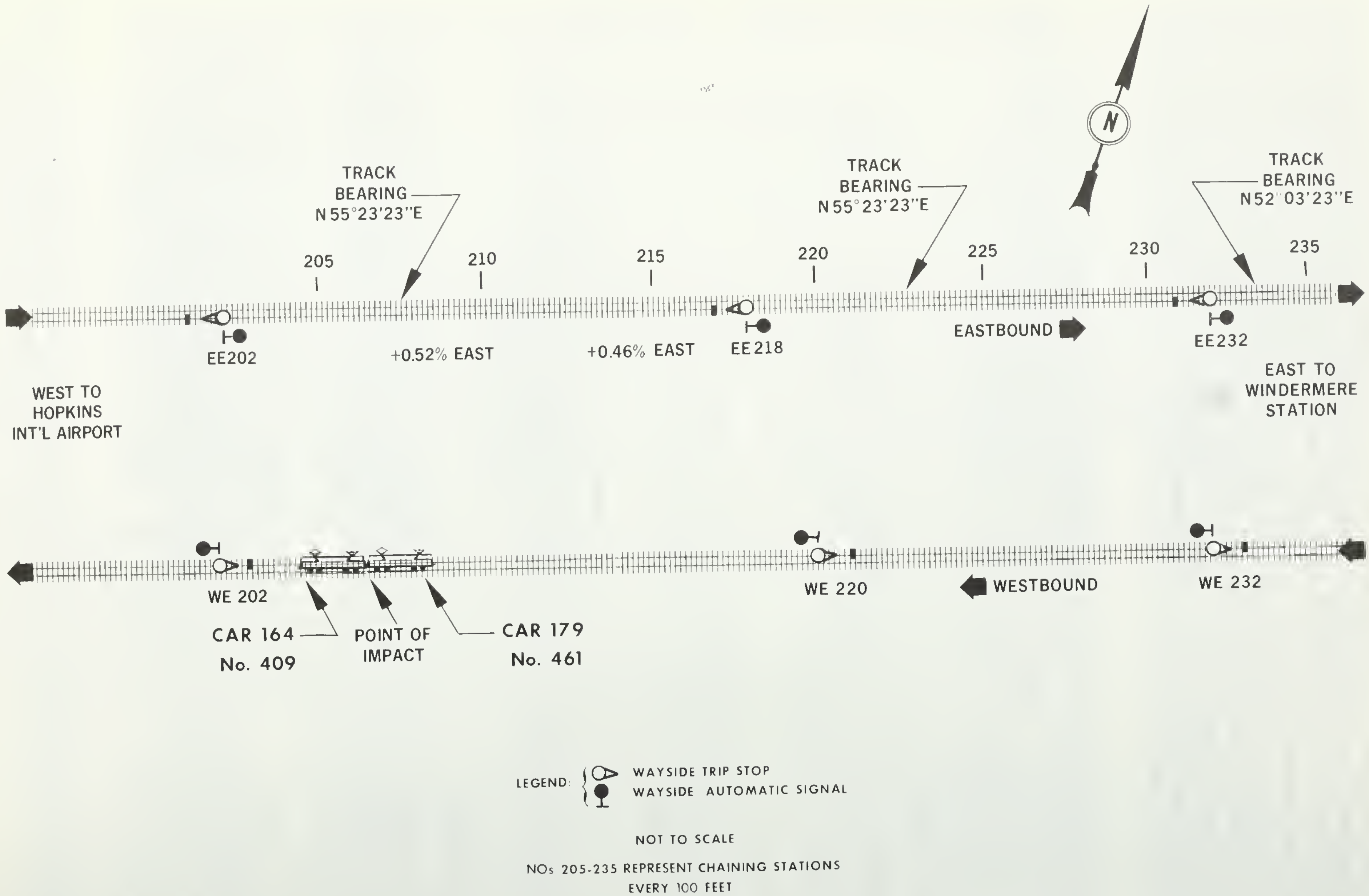

Figure 1. Plan view of accident site.

Figure 2. Damaged end of car No. 164 of train No. 409.

His last physical examination was on March 21, 1972, according to his personnel record; company rules require an annual physical examination.

The operator of No. 461 was employed as a bus operator by the predecessor of the RTA on November 16, 1973. Six months later he was assigned to the rail rapid transit operation for which he claimed he received 2 weeks training. He was required to operate trains under the supervision of qualified operators and to learn the signal indications. He was not required to pass a written examination. He did not receive a copy of the operating and safety rules, but was given an oral test on the rules during his training.

The operator of No. 461 served about 15 days suspension as penalties for missing runs, moving past red signals, leaving his train before arriving at the home terminal, and improper uniform, before this accident. His last physical examination was in June 1976.

Train Information

The cars are operated as single units or in multiple. They were built by Pullman Standard between 1967 and 1968. Each car is 70 feet long, is constructed of stainless steel, and weighs about 64,000 pounds. The ends of the cars have fiberglass sections. The cars are propelled by two General Electric electric traction motors on each truck. A pantograph on the roof of one end of the cars collects 600-volts d.c. power from the catenary system. The cars have operating compartments at each end. The 80-capacity seating is arranged so that seats face toward each end from the center of the car. Two double doors are located on each side near the ends of the cars.

The cars are equipped with General Railway Signal (GRS) automatic train control, automatic train stop, and cab signals. The ATS equipment will stop a train automatically if it strikes a raised trip arm at a signal.

Each cab of the car has a pilot light which lights when the doors are properly closed and all handbrakes are fully released. If the pilot light fails to light, it means all of these conditions are not met and the car does not receive propulsion power. A bypass button can be used to override the malfunction indicated by the pilot light and the car can proceed.

The train movement is controlled by a cineston lever which has positions for propulsion power, for brakes, and for coasting. The speedometers were reported by the operator of No. 461 and the off-duty operator to be erratic and undependable at low speed.

A blend of dynamic and pneumatic braking is provided. At about 8 mph the dynamic brake fades, and the braking becomes entirely pneumatic. The airbrake system is a Westinghouse R-2. After an emergency brake application, 30 to 40 seconds are needed to restore the air to release the brakes.

Maintenance records on car No. 179 of train No. 461 indicate that on January 24, 1976, three brakeshoes were replaced, on April 28, 1976, six brakeshoes were replaced, and on June 29, 1976, the brakes were adjusted. An air leak was repaired on the car's No. 1 tripcock on July 13, 1976, and on July 21, 1976, a leak was repaired at the brake pipe on the No. 1 truck.

Car No. 164 of train No. 409 was inspected March 15, 1976, May 11, 1976, and July 6, 1976. Minor repairs were made to the electrical, propulsion, and control systems. RTA routinely makes an operational inspection of its rail cars at 8,000 miles and at 24,000 miles, after which the cycle repeats.

Method of Operation

RTA's rapid transit division has two tracks which extend about 30 miles between Windermere in East Cleveland and Hopkins International Airport in West Cleveland. No records are made of trains when they pass control points. Central control and the tower operators maintain daily logs of trains and record any unusual events.

Trains are governed by indications of wayside signals with ATS between Windermere Station and West Park Station. Each signal's ATS trip arm is mounted a prescribed distance and height from the field side of the rail. It is lowered by an a.c. motor and held electromechanically. It is raised by spring action. In the raised position, it will engage and trip an arm on the train as it moves past and cause the brakes to be automatically applied. (See figures 3 and 4.)

A train in ATS territory is always protected from a following train by at least two red signals. The trip arm at the second red signal behind the train is raised, but the trip arm at the signal at the entrance to the occupied block is not raised. (See figure 5.)

To pass a signal with a raised trip arm, the operator can either detrain and manually latch the trip arm down or reduce the speed of his train to 1.5 mph or less in the 10-feet area between the insulated joint 3/ and the trip arm. This permits the trip arm to be electrically lowered before the train strikes it.

The operator is then required by rule to stop at the next red signal. After stopping, the train can proceed at a speed of 5 mph or less, and its operator should expect to find a train, an obstruction, or a broken rail ahead.

If the train equipment receives an improper ATC signal or no signal, or if there is an equipment failure, the train will automatically brake to a stop. At that point, if the ATC or cab signals are inoperative, the operator has the options of: (1) operating the train in a bypass mode; (2) moving at a slow speed limited by the ATC overspeed control; (3) or replacing the train equipment at the next yard or terminal. The system is made inoperative in non-cab-signal territory, but extraneous signals can actuate the system and cause the train to stop. This is probably what occurred at Windermere and Superior Stations. In order to move faster than 15 mph, or, for some type failures, in order to move at all, the ATC equipment has to be "cut out." The operation of the bypass control accomplishes this.

3/ An insulated joint electrically separates adjacent track circuits.

Figure 3. Automatic train stop arm on RTA car.

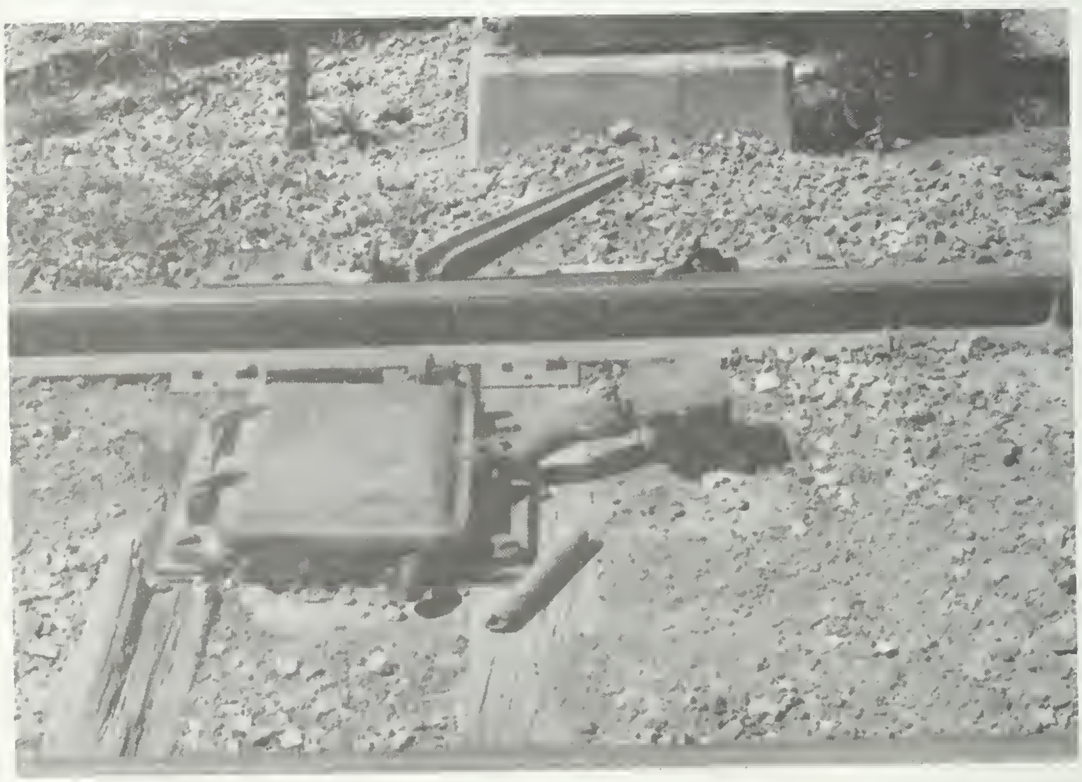

Figure 4. Wayside trip arm in trip position.

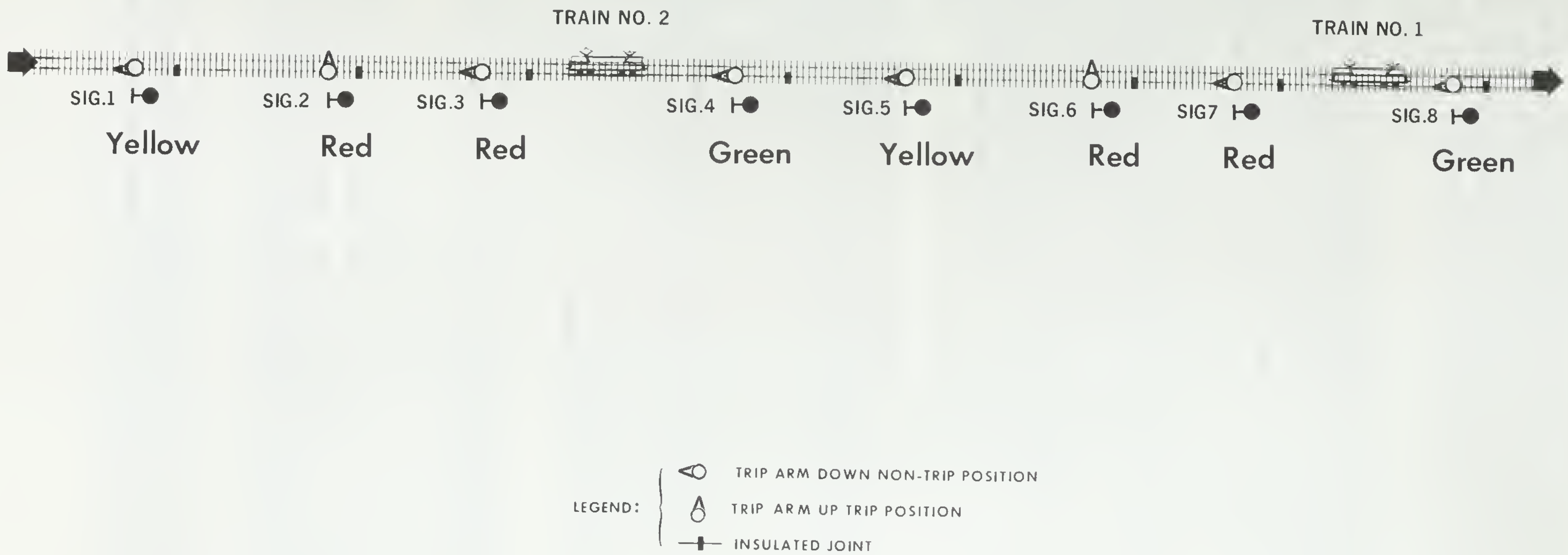

Figure 5. Operational sequence of automatic trip stops.

An RTA operating rules book per se does not exist. RTA provides a training and operations manual for use by its instructors in the classroom, but the book is not furnished to the operators. In its current form, it is more of an instruction manual giving the operators general information on operating techniques, features of the cars, use of the radio, and guidelines for operating and troubleshooting the equipment.

The manual does not have a composite grouping of all current operating rules. There are a few definitions for wayside and cab signal aspects with their indications, and a few hand signal requirements. The definition for speeds required by the various signal indications is not included in the manual. Changes to operating rules and procedures are disseminated by bulletins and general orders as necessary.

Employees were notified of changes in operating procedures by the posting of bulletins or general orders on bulletin boards at crew-change points, or if the changes were complex ones, copies were mailed or hand-delivered to those affected by the order. Temporary changes, such as the location of rough track or men working were written on a chalkboard or announced over the system's radio network. Each operator was responsible for reading and understanding such notices although acknowledgment of the notices was not required.

At the time of the accident, restricted speed was defined as 15 mph for movement in a "red" unoccupied block, and 5 mph in a "red" occupied block. The only speed requirement prescribed for operation in a block governed by a signal displaying an approach aspect was that the operator be able to stop the train at the red signal.

Since the accident the RTA has reduced the maximum speed to 10 mph in unoccupied "red" blocks. In addition, the RTA now requires an operator to come to a complete stop at a red signal that governs the entrance to an occupied block. The operator must obtain verbal permission from central control or a supervisor at the location before proceeding past the signal.

A company rule requires operators to report to central control any problem that might cause a 30-second delay or require that a train be taken out of service. Flagging is not required to protect standing trains.

Operators are not required to make predeparture tests of the ATC cab signal equipment. The equipment is supposed to be tested by maintenance personnel before the car is brought to the station to be dispatched in service. Operators inspect lights and other such items before beginning a run, but they do not inspect the brakeshoes nor do they test the brakes until after the train leaves the station.

The training program consists of 2 days of classroom instruction on the signals, rules and equipment, 3 days of on-the-job training under the guidance of a regular operator, and 1 day devoted to review, examinations, general instruction,

and familiarization. RTA employees are not required to take systematic reexaminations on operating rules and procedures after their initial training and 1-year probationary period. However, they are contacted periodically by instructors for a general discussion on "how things are going."

Meteorological Informaiton

The weather at the time of the accident on August 18, 1976, was clear and bright; visibility was good; the temperature was 76° F; and the rails were dry.

Survival Aspects

Since the injuries to passengers and crewmembers were cuts and abrasions, a crash-injury analysis was not performed. The damaged cars were pushed into the station at East 79th Street where persons who needed medical attention were removed and taken to hospitals.

There was no evidence of interior structural failures that could have contributed to passengers' injuries.

Tests and Research

The wayside signals involved were checked after the accident and were found to operate properly. The trip stop mechanisms were found to be properly located and were operating in proper sequence.

A test of the brake system of car No. 179 of train No. 461 failed to disclose any discrepancies. Stopping distances were within specifications and a test stop, made by deliberately running past a raised trip arm, was satisfactory. The car was also road tested, and it operated properly in all respects.

A broken roll pin in a door mechanism was found on car No. 164 of train No. 409 which prevented the door from closing properly. It could have caused the failure that was indicated by the pilot light.

The operator of No. 461 did not receive a medical examination after the accident. He was reported to be in a "responsible" condition by his management.

Other Information

RTA's safety department is not authorized to impose requirements on the operating department, but there is a good working relationship between the departments and a general acceptance of safety measures by the operating department.

Those operators who were deposed during the investigation of this accident showed an attitude of indifference to the operating and safety rules. They did not seem to understand the general indication conveyed by the signal aspects. Proper

terminology, and exact interpretation or application of the rules seemed irrelevant to them. Their understanding of the speed rules was vague. Their reference to the modes of operation was casual and they used colloquialisms to describe operational features and appurtenances.

The RTA is not regulated by a Federal or State regulatory body but its operating officers report to a Board of Directors.

ANALYSIS

Since the operator of No. 461 saw No. 409 standing at the East 105th Street Station platform, he knew that No. 409 was running only a short distance ahead of No. 461. Further, the necessity to lower the trip arm at signal WE 232 should have confirmed the presence of No. 409. In violation of the rules, the operator accelerated to about 30 mph and passed the red signal at the entrance to the occupied block without reducing speed. Train No. 409 was visible to the operator of No. 461 during this time, and he admitted that he was aware that No. 409 was stopped. His estimation of the distance he placed No. 409 beyond the second red signal, and his claims that he applied full service brakes at that time, but did not apply the emergency brakes until he was within 60 or 70 feet, indicate that the operator was not alert. Based on his testimony, he would have moved about 1,300 feet before applying the brakes in emergency.

The operator of No. 461 twice failed to obtain permission from RTA central control to operate the ATC bypass control. He also did not report the alleged ineffective brake applications, on the previous trip from Windermere, which he blamed for causing him to run past two station platforms during stops. He did not mention the brake performance on this trip at the station stops, when he stopped at the stop signal east of 105th Street Station, or when he slowed for the signal with its trip arm up. He properly observed the rules governing the movement of his train past the signal with its trip arm up, but from that point until the accident, he was operating in violation of the rules. The continued presence of the off-duty operator in the operating compartment also violated operating rules.

Based on his training and the method used by RTA to instruct train operators in rules and operating instructions, it is doubtful whether he knew of the requirement for permission to use the bypass button. His understanding of the rule and its application could have been vague, especially since the problem occurred in noncab-signalled territory. However, if just for his own personal safety, it seems he would have reported the braking problems he claimed he was experiencing.

The operator of No. 461 was inattentive to his task when he increased train speed after passing the first red signal and did not stop at the second red signal. He may have had an incentive to do this, thinking he would maintain a speed equal to that of the train ahead and thus avoid having to "time past" another stop signal, or he may have been distracted by the off-duty operator. The standing train's operator depended on the operator of the following train to obey the signals and operating rules.

A method should be employed to insure that an operator will stop his train before moving past the second stop signal. This could be accomplished by restricting trains from entering occupied blocks.

There were two major deficiencies in RTA's procedures which were directly reflected in the causal factors in this accident: (1) a poor, unverified system of disseminating operating rules and procedures which were inadequate, and (2) a failure to completely and continually instruct operators in the rules and procedures. A combination of these two deficiencies contributed to the apparent lack of concern observed in the deposed operators about the meaning and application of the operating rules and procedures.

Management has no system to insure that the operators have read bulletins or general orders, or that they understand them. Individuals must seek guidance from fellow operators, from whom one could be misinformed, or the nearest available line of supervision. There is a need for better communication between supervisors and the operating personnel in this respect. A consistently safe and efficient operation must be conducted in an atmosphere of concern with well defined, precise, and objective operating rules and procedures. RTA's documented rules and procedures did not give the supervisors and operators the necessary guidelines to insure that train operations would be conducted safely and efficiently. For example, the RTA's use of the ATS system did not insure protection for a train which may be overtaken.

The safety provided by the system is compromised where trains are allowed to pass a stop signal. It is possible for a train to "pace" a preceding train by moving just in advance of the signal with its trip arm up. Each train would be traveling through a block unprotected by a raised trip arm. When trains are operated in this manner, the safety responsibility is vested in the operator. Considering the fact that RTA does not provide personal copies of rule books to operators, nor provide a systematic review and retraining program to continually retrain them and to keep them conversant with the rules, the assignment to operators of the responsibility for safe train operation is not warranted.

On-the-job training as administered by RTA and as received by the operator of No. 461 does not insure that an employee is qualified to carry out the responsibility vested in him by the RTA system. Unstructured on-the-job training that is not administered and monitored closely by a qualified trainer does not offer the trainee the opportunity to learn all that he needs to know in order to be a safe and proficient operator. Indiscriminate on-the-job training leaves to chance the solution of important and critical problems to which the trainee may be exposed.

Only the operator of No. 461 knows whether he knew and understood the rules relative to operating in a red unoccupied and a red occupied signal block, but under the system in effect for training and reviewing these matters, management cannot be absolved from part of the responsibility for the accident.

If operators are to be responsible for complying with operating rules and procedures, they must be educated in them and their understanding of their applications must be confirmed by comprehensive examinations. Reexamination of operators must be regular and periodic, and must not be predicated on the observed violation of operating practices. RTA's current practice of reexamining operators after an observed violation of a rule is an after-the-fact procedure which is only partially effective in preventing accidents. Regular periodic reexaminations supplemented by regular efficiency checks by competent supervisors would compel operators to remain aware of the applications of the rules and procedures.

If a system were employed whereby a record is maintained to indicate that an employee has read a rule or procedure change bulletin, and if such system also indicated he understood the change, management would have a basis for the censure of violators.

Inherent in any effective system of education and reexamination is a thorough dissemination of documented rules and procedures. Changes and additions to such control documents must be provided in a manner which will assure that the affected persons receive and understand them. Regular efficiency checks by supervisors would determine the effectiveness of whatever system is used. RTA's practice of merely posting rules changes does not insure that operators receive, read, and understand the application of the rules.

Although the absence of a pre-departure check of safety features of the train cannot be related to the cause of this accident, it is apparent that, under RTA's procedures, a train could leave its initial terminal with malfunctioning equipment without the knowledge of the operator. It is not clear under the present RTA procedure if the operator can assume that, when he takes charge of a train, it has been prepared for service properly and all systems are functioning as intended. RTA needs to develop a procedure which assures an operator that he is starting a run with a train which will perform as intended.

The Federal Railroad Administration (FRA) has had the legislative authority since 1970 to "... prescribe as necessary appropriate rules, regulations, orders, and standards for all areas of railroad safety ..." 4/ This has been interpreted to include rail rapid transit systems. However, the FRA has not issued to rapid transit systems the appropriate regulations that are needed to promote standardization and to improve safety. Thus far, it has merely required that accidents occurring on these lines be reported to the FRA.

There is a need for operating standards and a system of checks and balances to insure conformance. Rapid transit systems are carrying great numbers of passengers daily whose personal safety depends on the safety afforded by the system. Every effort should be made to insure this safety. Ridership of operational rapid transit systems seems to be increasing. Also, there are a number of new systems under construction or being planned which will cause a further increase in riders. Because of the energy situation, it is likely that many new rapid transit systems will be constructed which will cause a continued growth in patronage.

4/ Public Law 91-458, The Federal Railroad Safety Act of 1970.

The present policy which allows each transit system to regulate and enforce its own safety program and to operate entirely from within the system is inadequate. It does not provide the system safety assurance that transit patrons are entitled to, nor does it promote standardization. Therefore, the FRA should not delay any longer in prescribing the safety rules, regulations, orders, and standards necessary to insure the safest transit systems possible for their riders and employees.

CONCLUSIONS

Findings

1. No. 409's car had no indicated deficiencies when it departed Windermere Station.

2. The operator of No. 409 did not notify central control that the pilot light would not light, though he intended to do so.

3. No. 461's car had no indicated deficiencies when it departed Windermere Station.

4. The operator of No. 461 did not notify central control that the ATC alarm had sounded and did not ask permission to operate the ATC bypass control. Also, he did not report any problem with the train brakes.

5. The operator of No. 461 saw No. 409 at a sufficient distance to have allowed him to stop before striking the train.

6. The operator of No. 461 operated his train in violation of the RTA operating rules after it moved past the stop signal with its trip arm up.

7. No faults were found in the prescribed technical operation of the ATS or signal system.

8. Post-accident tests on the car of No. 461 did not indicate any fault with the brake system.

9. The policy of having the trip arm down at a stop signal and allowing a train to move past it compromises the safety provided by the ATS system.

10. Employees are not required to acknowledge receipt and understanding of posted changes in operating procedures or rules.

11. Operators departing a terminal have no written record that the equipment has been tested and inspected and is safe for service.

12. RTA employees are not required to take systematic operating rules and procedures reexaminations.

13. The RTA is not regulated by a Federal or State body.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of train No. 461 to comply with the mandatory stop signal indication and to apply the brakes in emergency promptly after the train ahead had been sighted, and operation of the train at an excessive speed. Contributing to the probable cause was the lack of an effective operator training program and the ineffectiveness of the protective devices and procedures to prevent a following train from entering an occupied block.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended that the Greater Cleveland Regional Transit Authority:

> "Develop a system assurance and safety program that will provide and insure the following:
>
> 1. A set of operating rules and procedures that will provide objective requirements for a safe and efficient operation.
>
> 2. A training program that will originally acquaint operating personnel with the rules and a system of reexamination to keep them current with the rule requirements.
>
> 3. A system of supervision which will enforce the rules and will provide an efficient operation. (Class II, Priority Followup) (R-77-20)
>
> "Operate trains on an absolute block. If it becomes necessary to enter an occupied block in an emergency, provide procedures that will insure safe operation. (Class II, Priority Followup) (R-77-21)
>
> "Implement a system to insure that general orders and bulletins are read and understood. (Class II, Priority Followup) (R-77-22)
>
> "Expand the current test facilities for the ATC so that all equipment entering main track service can be tested, require more comprehensive inspections and tests to include all vital components or systems of the equipment, and provide a record of the results to the operator using the equipment. (Class II, Priority Followup) (R-77-23)"

The National Transportation Safety Board also recommended that the Federal Railroad Administration:

> "Establish operating and procedure standards for rail rapid transit systems. (Class II, Priority Followup) (R-77-24)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

BAILEY, Vice Chairman, filed the following concurring and dissenting statement:

I agree with most of the report and recommendations; however, I must dissent from the portion which asks FRA to promote standardization of mass transit systems. Mass transit systems, more than any other transportation mode, can't be standardized. Each system must fit the population configurations and traffic problems of its particular area.

I am convinced that a standard of performance is the first necessity, not necessarily design standards involving equipment as implied in "standardization" as used here. Many rail rapid transit systems are extremely well operated and with a high degree of proven safety; they do not necessarily meet a standardized design concept. But they do provide good, safe transportation. The ability to standardize systems that are so dissimilar in trackage, signals, cars and facilities as the New York City Transit Authority and the ultra-modern Washington METRO is highly questionable.

The second point on which I disagree with the majority is the following language on page 15:

> "The present policy which allows each transit system to regulate and enforce its own safety program and to operate entirely from within the system is inadequate. It does not provide the system safety assurance that transit patrons are entitled to, nor does it promote standardization."

I do believe philosophically in local control and local regulations. It is a misstatement to say this policy is wholly inadequate.

Some transit systems have operated extremely well for literally decades with almost unbelievably good safety records. When a system doesn't operate well and consistently fails to improve itself, then the need for regulatory discipline is obvious.

In order to have this expert guidance available, the regulatory powers of FRA should be activated. In view of the size of the industry and its diversity, I believe FRA should apply its efforts first to performance standard definition, then compare individual systems to the standard, and finally take action where required.

I do not agree with the appearance of our insistence on "standardization" as a cure-all, nor do I agree with a blanket statement that self-regulation is inadequate.

/s/ KAY BAILEY
Vice Chairman

August 4, 1977

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

HEAD-ON COLLISION OF TWO NORFOLK & WESTERN RAILWAY COMPANY FREIGHT TRAINS NEW HAVEN, INDIANA OCTOBER 19, 1976

REPORT NUMBER: NTSB-RAR-77-6

UNITED STATES GOVERNMENT

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15. Supplementary Notes

16. Abstract

About 9:15 p.m., on October 19, 1976, at New Haven, Indiana, Norfolk & Western Railway Company (N&W) freight train Extra 1376 West collided head-on with N&W yard locomotive unit No. 3363, which was pulling 55 freight cars. One locomotive unit, a caboose, and one car of Extra 1376 West, and the yard locomotive and one car were derailed. The brakeman on the locomotive of Extra 1376 West was killed and four crewmembers were injured. The estimated cost of damages was $168,400.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the crewmembers of Extra 1376 West to couple the airbrake hoses between the fifth and sixth cars from the rear, and to test the brakes as required by N&W rules and the Federal Power Brake Law of 1958.

As a result of its investigation, the Safety Board submitted one recommendation to the Norfolk and Western Railway Company.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: August 5, 1977

HEAD-ON COLLISION OF TWO NORFOLK & WESTERN RAILWAY COMPANY FREIGHT TRAINS NEW HAVEN, INDIANA OCTOBER 19, 1976

SYNOPSIS

About 9:15 p.m., on October 19, 1976, at New Haven, Indiana, Norfolk & Western Railway Company (N&W) freight train Extra 1376 West collided head-on with N&W yard locomotive unit No. 3363, which was pulling 55 freight cars. One locomotive unit, a caboose, and one car of Extra 1376 West, and the yard locomotive and one car were derailed. The brakeman on the locomotive of Extra 1376 West was killed and four crewmembers were injured. The estimated cost of damage was $168,400.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the crewmembers of Extra 1376 West to couple the airbrake hoses between the fifth and sixth cars from the rear, and to test the brakes as required by N&W rules and the Federal Power Brake Law of 1958.

INVESTIGATION

The Accident

About 5:55 p.m., on October 19, 1976, Norfolk & Western Railway Company (N&W) freight train Extra 1376 West departed Blair Yard, Fostoria, Ohio, westbound for Fort Wayne, Indiana. The train consisted of one locomotive unit, a caboose behind the locomotive, and eight cars. An initial terminal airbrake test made at Blair Yard before departure disclosed no defects. Extra 1376 West was operating as the westbound return portion of the local switching assignment between Fort Wayne, Indiana, and Fostoria, Ohio, known as the Blair Turn. This assignment had originated in Fort Wayne earlier in the day.

About 6:10 p.m., Extra 1376 West stopped at North Findlay, Ohio, and picked up seven cars which were added to the rear of the train. The flagman connected the airhoses between the seventh and eighth cars from the rear and then opened the angle cock on the former rear car. He then made a walking inspection of the additional seven cars but did not couple the airbrake hoses between the fifth and sixth cars from the rear. When he was in the vicinity of the main track about 200 feet from the rear car, he gave a hand signal to the engineer to move the train to the main track. When the train stopped, the flagman, while walking toward the locomotive, signalled the engineer to set and release the brakes on the train. He was near the ninth car from the rear end when he saw the brakes release.

The conductor was obtaining instructions from the dispatcher by telephone during the assembling of the train and did not observe any of the airbrake tests. The conductor got on the caboose as the train proceeded west about 6:35 p.m.

The train later stopped at Continental and Payne, Ohio, and Edgerton, Indiana, to set out and pick up cars. At each stop the seven cars picked up at North Findlay were not changed. All cars which were subsequently added or set out were located between the locomotive and these last seven cars. The traincrew stated that they never saw the brakes set or release on the last car of the train during any of the airbrake tests.

At 9:04 p.m., when the train left Edgerton with the locomotive, caboose, and 11 cars, one of the crewmembers radioed the dispatcher that they had completed their work and would be coming straight into the yard. The dispatcher acknowledged the message by saying "all right." The dispatcher had already activated signal circuits to allow Extra 1376 West to come as far as the west switch of the New Haven, Indiana, passing track.

Previously, the East Wayne yardmaster had received authority from the dispatcher to send yard engine 3363 with 55 cars east to the New Haven passing track. At 9:09 p.m., the dispatcher activated the circuit to cause eastbound signal 10R at the west switch of the New Haven passing track to change from a "stop" to a "proceed" aspect and lined the west passing track switch for the passing track. This action caused the westbound signal 10L at the west switch to display "stop," caused westbound signal 12L at the east switch of the passing track to display "approach," and caused the westbound signal 360.9 to display "advance approach." (See figure 1.)

The engineer of Extra 1376 West stated that after he saw that signal 12L displayed "approach," he made a full service brake application while his train was still 1,500 feet east of the signal, and he reduced throttle as the train passed the signal. However, Extra 1376 West passed signal 12L while moving about 60 mph and continued west for about 3,000 feet while reducing its speed less than 10 mph.

The crewmembers in the caboose stated that they felt the slowing of the train and, consequently, they felt no special action was necessary. When the engineer felt that the train was not slowing adequately, he asked the brakeman on the other side of the cab what speed was shown on his speed indicator because at times the engineer's speed indicator was sticking. The brakeman replied "50 mph." However, the engineer stated that the brakeman's speed indicator was not functioning properly, and would indicate 50 mph when the train was actually travelling 60 mph. The engineer then made an emergency brake application and told the brakeman that they were in trouble. The brakeman radioed yard engine 3363: "eastbound at New Haven, stop your train. We don't have any air." He then ran onto the rear platform of the locomotive.

The crew on the yard engine jumped from their train when they heard the radio message from Extra 1376 West. They were about 250 feet west of signal 10R

and still moving about 10 mph. Extra 1376 West passed signal 10L, which displayed "stop", and continued west 990 feet where it collided with yard locomotive 3363. The trains collided about 9:15 p.m., 6 feet west of the point of switch at the west end of the New Haven passing track, while both were moving about 10 mph. (See figure 1.)

The collision caused the east end of the locomotive unit of Extra 1376 West to jackknife to the north. The caboose was crushed between the south side of the locomotive and a loaded covered hopper car. A fire began in the caboose after the collision when the caboose stove oil ignited. Yard locomotive 3363 and the first car derailed.

The single main track is straight for about 3 miles to the point of collision and for 1 mile westward. A turnout connects the west end of the New Haven passing track with the main track 2.3 miles east of East Wayne Yard. The grade for westbound trains averages 0.17 percent, descending, for three-fourths of a mile east of the accident point and is nearly level for 1 1/4 miles farther east.

Injuries to Persons

Injuries	Crewmembers	Passengers	Other
Fatal	1	0	0
Nonfatal	4	0	0
None	3	0	

Damage

The locomotive unit of Extra 1376 West was damaged on both ends. The center sill and the end of the covered hopper car was bent. The caboose was destroyed. The yard locomotive unit 3363 was moderately damaged on both ends and the center sill of a boxcar, the first car, was damaged.

The collision damaged 130 feet of track, part of one switch, a switch machine, and some signal and communication cable. Cost of the damages was estimated as follows:

Locomotive	$120,000
Car	25,000
Track & Signal	23,400
Total	$168,400

Crewmember Information

The engineer of Extra 1376 West was 62 years old. His last physical examination, in May 1976, disclosed no defective physical conditions. He had been employed by the N&W for 37 years and had been operating locomotives for 33 years. He had been operating a locomotive in yard service since April 1975. His last instruction on the N&W operating rules was in May 1975.

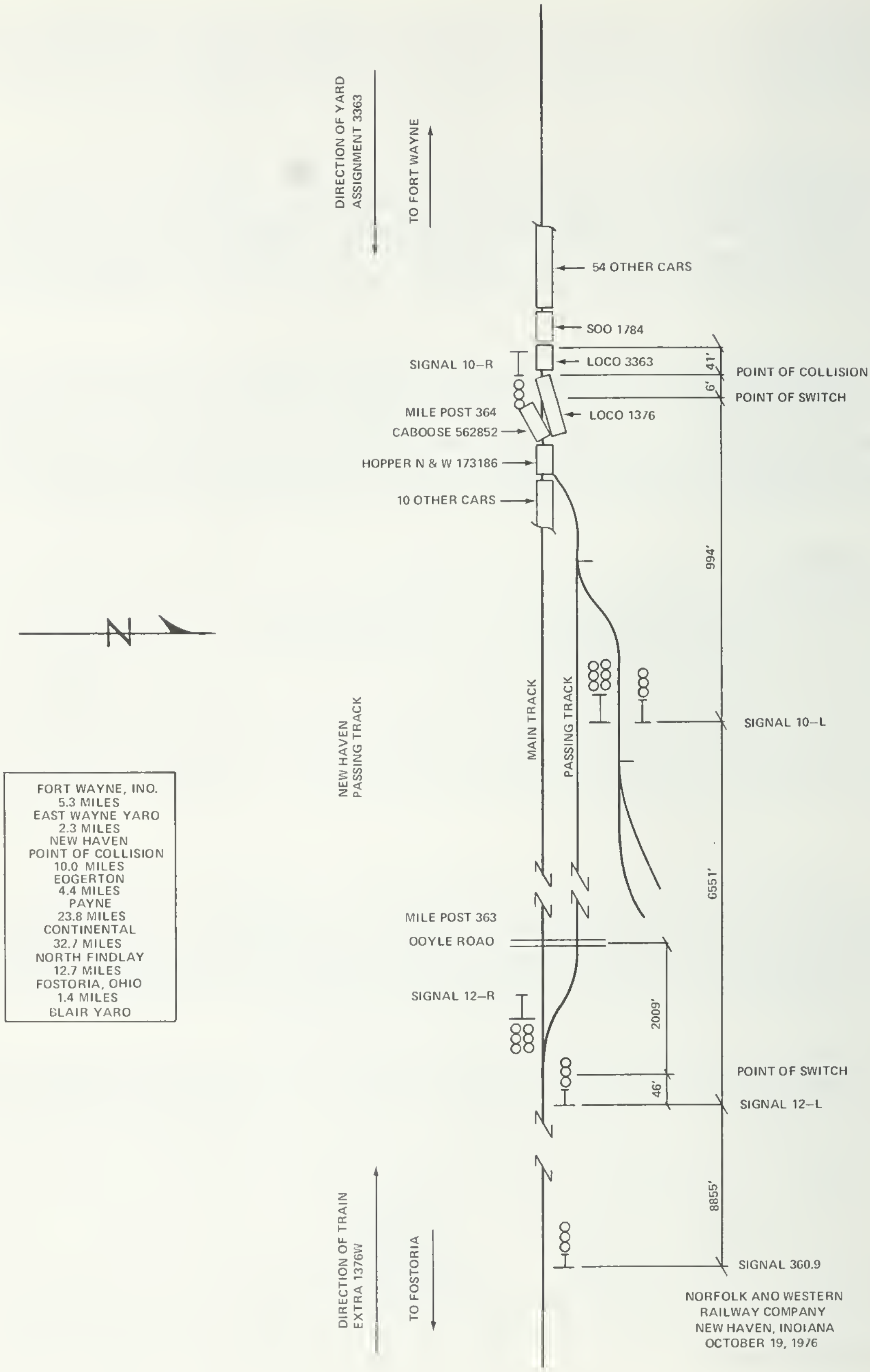


Figure 1. Track layout at and near accident site.

The engineer was assigned the run between Fostoria and Fort Wayne on October 6, 1976, and he took the required N&W territory familiarization run between these cities with another engine crew shortly before assuming his position. N&W rules did not require him to operate a locomotive in road service in the presence of a N&W supervisor or to pass any rules examination, written or oral, prior to changing his job assignment.

The front brakeman was 22 years old and had been employed by the N&W for 3 1/2 years. The conductor was 53 years old and had been a conductor for 25 years. The flagman was 57 years old, had been employed by the N&W for 23 years, and was a promoted conductor for 18 years. Their last instruction on the N&W rules was during the latter months of 1975.

The crewmembers had been off duty for about 12 hours when they reported for the Blair Turn assignment at the East Wayne Yard at 10:30 a.m. on October 19, 1976. Other N&W employees reported that the crewmembers of Extra 1376 West appeared to be well rested and fit for duty.

Train Information

The GP-40 diesel-electric locomotive unit of Extra 1376 West had dual operating controls which enabled the engineer to sit on the right-hand side of the cab when operating the locomotive in either direction. The unit had dynamic brakes, No. 26-L airbrake system, crew call-type safety device, a speed indicator on each side of the cab for use with the dual operating controls, speed recording equipment, and a radio with which the locomotive crewmembers could communicate with crewmembers on the caboose, on other trains, and with the train dispatcher.

Yard engine 3363 was a SW-9 diesel-electric locomotive with No. 6-BL airbrake system and a radio similar to the one on Extra 1376 West. The locomotive unit was not equipped with dynamic brakes or a speed indicator. The crewmembers were not provided with portable radios or a caboose.

The caboose of Extra 1376 West was equipped with a radio similar to the radio in the locomotive unit. The crewmembers were not provided with a portable gauge for measuring brake pipe air pressure or a speed indicator in the caboose.

Method of Operation

Trains operate over the 80.5-mile section of single track line between the East Wayne Yard and Blair Yard by signals of a traffic control system. The controlled signals and switches are operated by the dispatcher at the East Wayne Yard in Fort Wayne, Indiana. The dispatcher is permitted to radio train orders to traincrews; all radio communications with the dispatcher are recorded.

The maximum authorized speed for freight trains in the area is 60 mph.

Meteorological Information

The pickup of seven cars at North Findlay occurred at dusk while it was raining. The collision occurred in darkness while overcast with light rain. Visibility was about 2 miles, and the temperature was 42° F.

Survival Aspects

The brakeman, who radioed the yard crew and then ran from the locomotive cab of Extra 1376 West, was killed. He was crushed on the rear platform of the locomotive when the west end of the caboose raised upward and telescoped into the south corner of the locomotive. The engineer of Extra 1376 West sustained hip and wrist injuries when the collision impact threw him from his seat against the locomotive control panel. He had to evacuate the locomotive through his cab window because the closed cab doors became jammed in the collision.

The conductor of Extra 1376 West incurred a concussion, laceration of scalp and elbows, and second-to third-degree burns on about 25 percent of his body. He was knocked unconscious when he apparently hit his head on the caboose desk at which he was seated. The crewmembers of the yard crew rescued him from the burning caboose. The flagman of Extra 1376 West, who was on the rear steps of the caboose, was thrown from the steps and sustained bruised ribs and lacerations when he hit the ground. The yard crew conductor injured his right shin when he jumped to the ground from the moving yard locomotive.

Tests and Research

An inspection of Extra 1376 West about 1 hour after the collision disclosed that the angle cock was closed on the air line on the east end of the sixth car from the rear of the train, and the airhoses were not connected. It was also found that the brakes were not set and there was no air in the brake system of the last five cars.

The braking system of the undamaged cars and the airbrake components of the locomotive unit 1376 were tested and no defects were found. An examination of the speed recorder tape disclosed that it was not recording properly at the time of collision.

Stopping distance tests were performed with a train similar to Extra 1376 West, using variations in speed and airbrake applications but on a section of track with a different track grade. The tests revealed that, traveling at 60 mph and with full service brake application, the train could stop in 3,482 feet on dry track with brakes applied on the engine and all cars, in 4,179 feet with no brakes applied on the last five cars, in 6,695 feet with no brakes applied on the engine and last five cars, and in 4,081 feet under an emergency brake application with no brakes on the last five cars. A test also revealed that, traveling at 30 mph and with a full service brake application, a train could stop in 1,182 feet with no brakes on the last five cars. (See appendix B.)

Tests performed on the signal system revealed the signals were functioning as intended before the accident.

ANALYSIS

The seven cars picked up at North Findlay only had the airbrakes applied on the two lead cars when they were coupled to the existing eight cars of the train. Since the airhoses were not connected between the fifth and sixth car from the rear, and since the angle cock was closed on the east end of the sixth car, the flagman could not have seen the brakes apply and release on the last five cars of the train when he later gave the engineer a signal to apply and release the brakes. His subsequent observation of the brake cylinder release on the ninth car from the rear, while walking toward the locomotive, does not indicate that the air was applied throughout the entire train. Because the brake system functioned properly from the locomotive up to the fifth car from the rear, the engineer was not aware that the last five cars did not have brakes.

The Federal Power Brake Law requires that the brakes on each car added to a train must be inspected to determine among other things, that each applies and releases. (See appendix C.) In addition, the law requires that after the adding or setting out of cars in the train, an application and release of the brakes on the last car must be observed to determine that the brakes on all cars can be controlled by the engineer.

While Extra 1376 West performed its switching assignments at Continental, Payne, and Edgerton, the seven cars picked up at North Findlay remained coupled together at the rear of the train. Consequently, with the caboose remaining coupled to the locomotive unit, and the switching of cars being done between the last seven cars and the locomotive, the traincrew riding in the caboose did not observe whether the airbrakes on the rear car of the train functioned. Neither was a test made as required by the Federal Power Brake Law, to determine whether the brakes on all cars were under control of the engineer.

The N&W has prescribed rules for crewmembers responsible for performing necessary airbrake tests. (See appendix D.) According to these rules the crewmembers of Extra 1376 West were responsible for performing their train airbrake tests between terminals. The conductor, who has general charge of the train, should see that the brake tests are performed properly. The engineer, who is responsible for the safe operation of the locomotive, depends upon the trainmen to see that necessary brake tests on the cars are satisfactorily performed. The engineer should receive proper hand signals or radio communication from other crewmembers for applying and releasing the airbrakes during a test. A "proceed" signal is given the engineer upon completion of the tests, indicating to him the test has been satisfactory. The proceed signal was given the engineer of Extra 1376 West each time after switching and brake-testing cars at stations between North Findlay and the collision point.

The N&W rules do not describe how crewmembers will specifically comply with the Power Brake Law when the caboose is placed in a train other than on the rear. The crewmembers of Extra 1376 West failed to comply with the requirements of 49CFR232.13(d)-(1) when they did not determine the air pressure on the rear of the train before starting the brake test and failing to observe the application and release of the brakes on the rear car. If it is desirable to place the caboose in a position other than on the rear, some form of a portable gauge must be provided so that compliance with the Power Brake Law can be achieved.

For many years the N&W has placed the caboose directly behind the locomotive and ahead of the cars on the Blair Turn assignment. The N&W advised that this arrangement facilitates moving the train between terminals and makes switching moves easier by eliminating the need to uncouple the caboose before adding cars to the train and by having the crewmembers in the vicinity of the head end. However, regardless of the location of the caboose, the rules still require that the crewmembers insure that the train brake system has adequate air pressure before starting the brake tests and that they observe the rear car of the train after adding cars at intermediate points to see if the brakes apply and release. If the crewmembers had been furnished a portable air gauge or if the caboose with its air gauge had been located at the rear of Extra 1376 West, the crewmembers should have noticed that the airhoses were not coupled between the fifth and sixth cars from the rear.

Because of the small size of Extra 1376 West, there was no need for its engineer to take any physical action to immediately comply with the "advance approach" signal indication as the train passed signal 360.0. N&W operating rule 282-A permitted the engineer to proceed while preparing to stop at the second signal. The full-service brake application, which the engineer made 1,500 feet east of the next signal (12L), and the throttle reduction made while passing the signal should have been satisfactory for a train with a consist like that of Extra 1376 West to comply with the rules, since the stop signal (10L) was 8,051 feet west of the point of initial brake application.

Tests indicated that a train similar to Extra 1376 West, but with full braking capabilities, should have stopped in about 3,500 feet after a full-service brake application. With brakes on all cars, an engineer would not have needed to apply the brakes in full service until the locomotive was 3,000 feet past the "approach" signal to comply with signal 10L. The tests also indicated that a train with a consist similar to that of Extra 1376 West, but with the brakes on the rear five cars inoperative and the engine brake released, required about 6,700 feet to stop with a full-service brake application from 60 mph. This indicates that the engineer did not apply the brakes at the point he claims.

Extra 1376 West passed a stop and stay signal (10L) when the yard locomotive was about 300 feet west of the point of collision and still moving at 10 mph. The related slight damage to both trains verifies the fact that this was a low-speed collision. A test made of the emergency stopping distance with a train similar in consist to Extra 1376 West, with no brakes on the last five cars, stopped in 4,081 feet from 60 mph. This test indicated that the engineer of Extra 1376 West applied the brakes in emergency 3,960 feet east of the point of collision which is 2,970 feet

east of the stop signal 10L. This indicated that the engineer did apply the brakes at a point where the train would have stopped short of the collision point if Extra 1376 West had brakes on all units.

Crewmembers aboard yard locomotive 3363 operated their train in accordance with N&W rules. They received the radio information about poor braking from Extra 1376 West too late to take any action which would have prevented the collision.

The conductor and flagman of Extra 1376 West felt the train slowing as it passed the approach signal and assumed that the engineer was handling the train properly. However, the conductor had no device in the caboose to indicate the speed of the train; he had to rely on his judgment and could not monitor the engineer and the front brakeman.

The Federal Railroad Adminsitration is currently processing a citation against the Norfolk & Western Railway Company for violation of the Federal Power Brake Law.

CONCLUSIONS

Findings

1. The airhoses were not coupled between the fifth and sixth cars from the rear of Extra 1376 West and the angle cock was closed on the east end of the sixth car from the rear of the train when Extra 1376 West left North Findlay.

2. The traincrew of Extra 1376 West did not determine if the train brake system was properly charged as indicated by a gauge at the rear of the train after switching cars at stations between North Findlay and New Haven.

3. The traincrew of Extra 1376 West did not determine if the brakes would apply and release on the last car of their train after switching cars at stations between North Findlay and New Haven.

4. The N&W did not provide means for the crewmembers to comply with the requirements of the Federal Power Brake Law of 1958 to determine after adding cars, that the train brake system was charged properly as indicated by a gauge on the rear of the train.

5. The uncoupled airhoses and closed angle cock would have been found by the crewmembers of Extra 1376 West if company rules and Federal inspection requirements had been followed.

6. An initial full-service automatic brake application was not made 1,500 feet east of signal 12L.

7. An initial automatic brake application 1,500 feet east of "approach" signal 12L for Extra 1376 West was not required according to rule 282-A.

8. The reaction of the engineer to the inadequate braking of Extra 1376 West was too late to prevent the collision by an emergency brake application.

9. There was sufficient distance for Extra 1376 West to have stopped before the collision point when the emergency brake application was made if the train had had full braking capability.

10. The crewmembers of the yard locomotive operated their train in accordance with the rules of the N&W and could not have prevented the accident.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the crewmembers of Extra 1376 West to couple the airbrake hoses between the fifth and sixth cars from the rear, and to test the brakes as required by N&W rules and the Federal Power Brake Law of 1958.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board submitted the following recommendation to the Norfolk & Western Railway Company:

> "Establish policy and procedures that will insure that all trains are operated in compliance with the company's rules and the Federal power brake regulations. (Class II, Priority Followup)(R-77-25)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

August 5, 1977

APPENDIX A

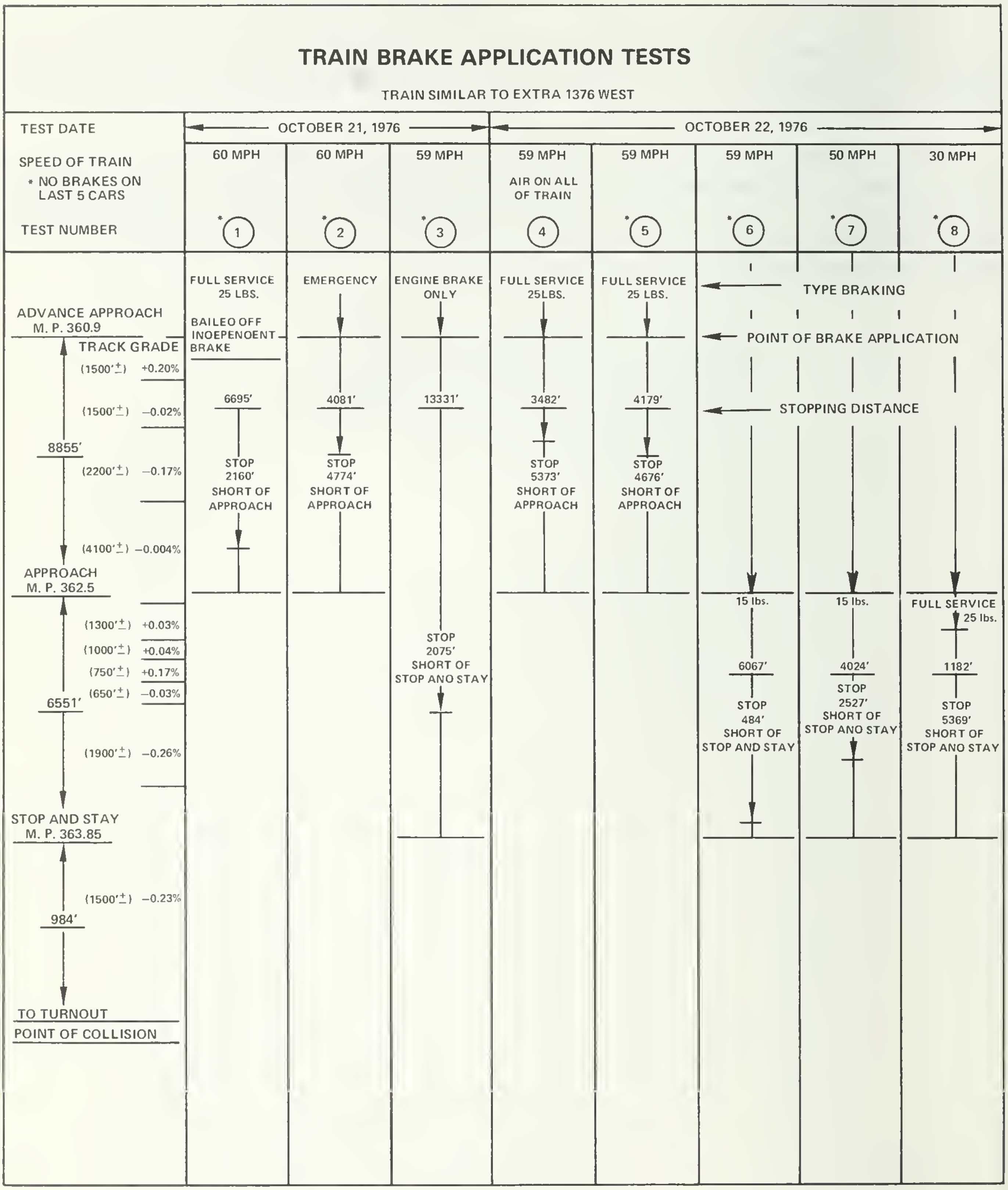
INVESTIGATION

The accident described in this report was designated a major accident by the National Transportation Safety Board under the criteria established by the Safety Board's regulations.

This report is based on facts obtained from an investigation conducted by the Safety Board with the assistance of other agencies. The Safety Board wishes to acknowledge the excellent cooperation extended by the following agencies during the investigation of this accident and the taking of witnesses' statements at Fort Wayne, Indiana, beginning on February 24, 1977:

Indiana Public Service Commission
Federal Railroad Administration
Norfolk & Western Railway Company
Brotherhood of Locomotive Engineers
United Transportation Union

APPENDIX B


TRAIN BRAKE APPLICATION TESTS
TRAIN SIMILAR TO EXTRA 1376 WEST
TEST DATE
OCTOBER 21, 1976
OCTOBER 22, 1976
SPEED OF TRAIN
* NO BRAKES ON LAST 5 CARS
TEST NUMBER
60 MPH
60 MPH
59 MPH
59 MPH
AIR ON ALL OF TRAIN
59 MPH
59 MPH
50 MPH
30 MPH
*1
*2
*3
4
*5
*6
*7
*8
FULL SERVICE 25 LBS.
BAILEO OFF INOEPENOENT BRAKE
EMERGENCY
ENGINE BRAKE ONLY
FULL SERVICE 25LBS.
FULL SERVICE 25 LBS.
TYPE BRAKING
POINT OF BRAKE APPLICATION
STOPPING DISTANCE
ADVANCE APPROACH M. P. 360.9
TRACK GRADE
(1500'±) +0.20%
(1500'±) –0.02%
8855'
(2200'±) –0.17%
(4100'±) –0.004%
6695'
STOP 2160' SHORT OF APPROACH
4081'
STOP 4774' SHORT OF APPROACH
13331'
3482'
STOP 5373' SHORT OF APPROACH
4179'
STOP 4676' SHORT OF APPROACH
APPROACH M. P. 362.5
(1300'±) +0.03%
(1000'±) +0.04%
(750'±) +0.17%
(650'±) –0.03%
6551'
(1900'±) –0.26%
STOP 2075' SHORT OF STOP ANO STAY
15 lbs.
6067'
STOP 484' SHORT OF STOP AND STAY
15 lbs.
4024'
STOP 2527' SHORT OF STOP ANO STAY
FULL SERVICE 25 lbs.
1182'
STOP 5369' SHORT OF STOP ANO STAY
STOP AND STAY M. P. 363.85
(1500'±) –0.23%
984'
TO TURNOUT
POINT OF COLLISION

APPENDIX C

Excerpts from Code of Federal Regulations, Title 49, Chapter II - Federal Railroad Administration, Part 232 - Railroad Power Brakes and Drawbars

*****

232.1 Power brakes: minimum percentage.

On and after September 1, 1910, on all railroads used in interstate commerce, whenever, as required by the Safety Appliance Act as amended March 2, 1903, any train is operated with power or train brakes, not less than 85 percent of the cars of such train shall have their brakes used and operated by the engineer of the locomotive drawing such train, and all power-brake cars in every such train which are associated together with the 85 percent shall have their brakes so used and operated.

*****

232.13 Road train and intermediate terminal train air brake tests.

(a) Passenger trains: Before motive power is detached or angle cocks are closed on a passenger train operated in either automatic or electro-pneumatic brake operation, except when closing angle cocks for cutting off one or more cars from the rear end of train, automatic air brake must be applied. After recoupling, brake system must be recharged to required air pressure and before proceeding and upon receipt of proper request or signal, application and release tests of brakes on rear car must be made from locomotive in automatic brake operation. If train is to be operated in electro-pneumatic brake operation, this test must also be made in electro-pneumatic brake operation before proceeding. Inspector or trainman must determine if brakes on rear car of train properly apply and release.

(b) Freight trains: Before motive power is detached or angle cocks are enclosed on a freight train, brakes must be applied with not less than a 20 pound brake pipe reduction. After recoupling and angle cocks are opened, it must be known that brake pipe air pressure is being properly restored as indicated by the caboose gauge and that brakes on rear car are released. In the absence of a caboose gauge, air brake test must be made as prescribed by that portion of paragraph (a) of this section pertaining to automatic brake operation.

(c) (1) At a point other than initial terminal where locomotive or caboose is changed, or where one or more consecutive cars are cut off from rear end or head end of train with consist otherwise remaining intact, after train brake system is charged to within 15 pounds of feed valve setting on locomotive but not less than 60 pounds as indicated at rear of freight train, and on a passenger train to at least 70 pounds, a 20 pound brake pipe reduction must be made and it must be determined that brakes on rear car apply and release properly.

(2) Before proceeding it must be known that brake pipe pressure as indicated at rear of freight train is being restored.

*****

(d) (1) At a point other than a terminal where one or more cars are added to a train, and after the train brake system is charged to not less than 60 pounds as indicated by a gauge at the rear of freight train and on a passenger train to not less than 70 pounds, tests of air brakes must be made to determine that brake pipe leakage does not exceed five (5) pounds per minute as indicated in the brake pipe gauge after a 15 pound brake pipe reduction. After the leakage test is completed, brake pipe reduction must be increased to full service, and it must be known that the brakes on each of these cars and on the rear car of train apply and release. Cars added to train which have not been inspected in accordance with 232.12(c)-(j) must be so inspected and tested at next terminal where facilities are available for such attention.

*****

APPENDIX D

Excerpts from Norfolk & Western Railway Company "Operating Rules" and "Rules for Equipment Operation and Handling"

*****

A-4. Each train must have the air brakes in effective operating condition, and at no time shall the number of operative air brakes be less than 85 percent. When piston travel on a car is in excess of 10 inches, the air brakes on the car cannot be considered in effective condition.

*****

A-12 When the locomotive of a freight train has been detached and after recoupling to the train, it must be known that the brake pipe pressure is being restored as indicated by a gauge at the rear of train and that the brakes have released on the rear car.

In the absence of a gauge at the rear end of a train, air brake test must be made to determine that brakes on the rear car can be applied and released from the locomotive automatic brake valve and observed by inspector or trainman before proceeding.

A-13 At a point other than initial terminal, after setting off one or more consecutive cars from the rear end or head end, or changing the locomotive, and the remainder of the train consist is otherwise intact, the train air brake system must be charged to within 15 pounds of the feed valve or regulating valve setting on locomotive, but not less than 60 pounds as indicated at the rear of freight trains, and on a passenger train to not less than 70 pounds.

After the required brake pipe pressure is obtained, a 20-pound service brake pipe reduction must be made to determine that brakes on rear car apply and release. Before proceeding, it must be known that brake pipe pressure as indicated at rear of freight train is being restored.

A-14 At a point other than a terminal where one or more cars are added to a train, and after the train brake system is charged to not less than 60 pounds as indicated by a gauge at the rear of freight train and on a passenger train to not less than 70 pounds, tests of air brakes must be made to determine that brake pipe leakage does not exceed five (5) pounds per minute as indicated by the brake pipe gauge after a 15-pound brake pipe reduction. After the leakage test is completed, brake pipe reduction must be increased to full service, and it must be known that the brakes on each of these cars and on the rear car of train apply and release. Cars added to train which have not been inspected in accordance with Rule A-6 must be so inspected and tested at next terminal where facilities are available for such attention.

*****

A-34 Crew members on the caboose must observe the caboose gauge frequently and where such observations indicate danger, they must take prompt action to stop the train.

A-35 Air brakes must not be cut out on two consecutive cars in a train.

*****

*****

CONDUCTORS

*****

555. They have general charge of the train to which assigned and all persons employed thereon are subject to their instructions.

They must, when necessary, instruct other members of their crew as to the proper performance of their duties.

*****

ENGINEMEN

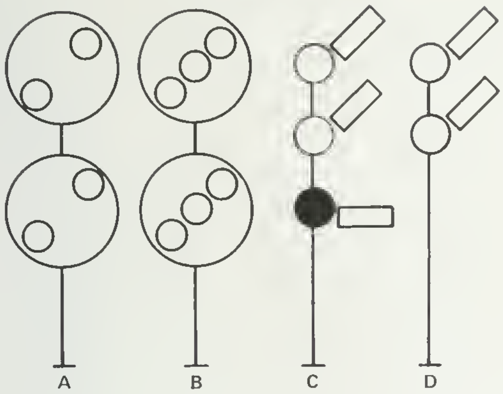
*****

588. The engineman will be held responsible for the safe and efficient operation of the engine in his charge. The engineman must not leave the engine during his tour of duty, except in case of necessity, and then only when necessary precautions have been taken to protect the equipment.

Rule 282—A

NOTE: INDICATES COLOR RED

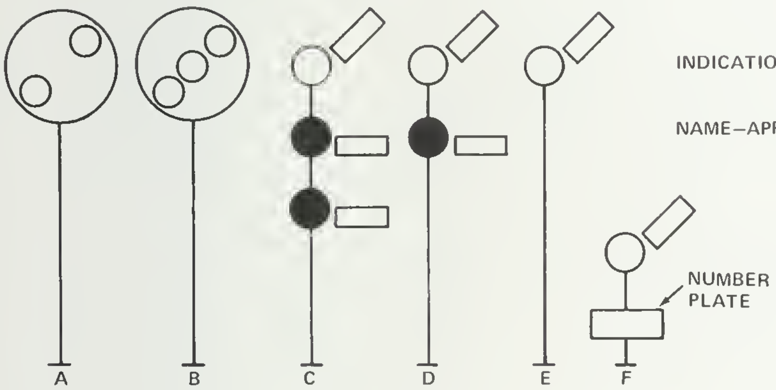
INDICATES COLOR YELLOW



INDICATION— PROCEED PREPARING TO STOP AT SECOND SIGNAL.

NAME—ADVANCE APPROACH.

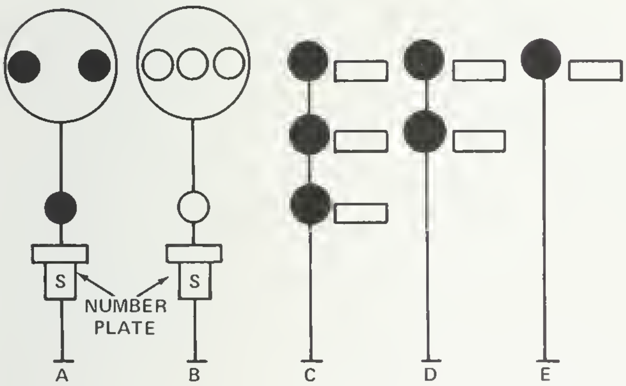
Rule 285

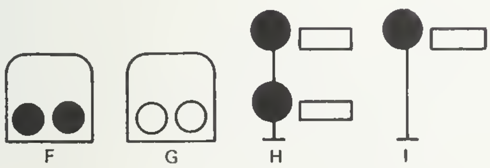


INDICATION—PROCEED PREPARING TO STOP AT NEXT SIGNAL. IF EXCEEDING MEDIUM SPEED IMMEDIATELY TAKE ACTION TO REDUCE TO THAT SPEED.

NAME—APPROACH.

Rule 292





INDICATION—STOP AND STAY.

NAME—STOP AND STAY.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

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WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF A BURLINGTON NORTHERN FREIGHT TRAIN

BELT, MONTANA

NOVEMBER 26, 1976

REPORT NUMBER: RAR-77-7

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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15. Supplementary Notes

16. Abstract

About 2:55 p.m. on November 26, 1976, 24 cars of Burlington Northern freight train Extra 5743 East derailed at Belt, Montana. Twenty-two persons were injured as a result of the accident and two persons are missing. About 200 people were evacuated because of subsequent fires and explosions. Five houses, a Farmers Union Cooperative facility, and several other buildings were destroyed or damaged. Nineteen motor vehicles were destroyed and Belt Creek was contaminated. Damage was estimated to be $4,540,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: September 29, 1977

DERAILMENT OF A BURLINGTON NORTHERN FREIGHT TRAIN AT BELT, MONTANA, NOVEMBER 26, 1976

SYNOPSIS

About 2:55 p.m. on November 26, 1976, 24 cars of Burlington Northern freight train Extra 5743 East derailed at Belt, Montana. Twenty-two persons were injured as a result of the accident and two persons are missing. About 200 people were evacuated because of subsequent fires and explosions. Five houses, a Farmers Union Cooperative facility, and several other buildings were destroyed or damaged. Nineteen motor vehicles were destroyed and Belt Creek was contaminated. Damage was estimated to be $4,540,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

INVESTIGATION

The Accident

About 1:40 p.m., on November 26, 1976, Burlington Northern (BN) freight train Extra 5743 East departed from Great Falls, Montana, eastward 1/ on the single-track mainline for Mossmain, Montana. The train consisted of 5 locomotive units and 121 cars. Inspections and brake tests performed before the train departed, and numerous inspections made by the crewmembers en route, disclosed no defects.

About 2:55 p.m., the train was moving at 38 mph as its locomotive passed the station at Belt, Montana, 26.5 miles south of Great Falls. The engineer did not observe any defects in the track as the train approached and crossed a bridge over Castner Street. A few moments later, the fireman looked to the rear of the train and saw a boxcar derail near the bridge. He reported this to the engineer and then saw more cars derail, including several tank cars. The derailment initiated an emergency brake application. The locomotive and 28 cars stopped about 3,002 feet south of the point of derailment, 3,493 feet south of the Belt station, and 3,000 feet from the north end of the bridge. (See figure 1.) Twenty-four cars, the 29th through the 52nd, derailed. None of the crewmembers were injured in the accident.

1/ This direction is related to BN timetable directions. At Belt a BN eastbound train is traveling southward geographically.

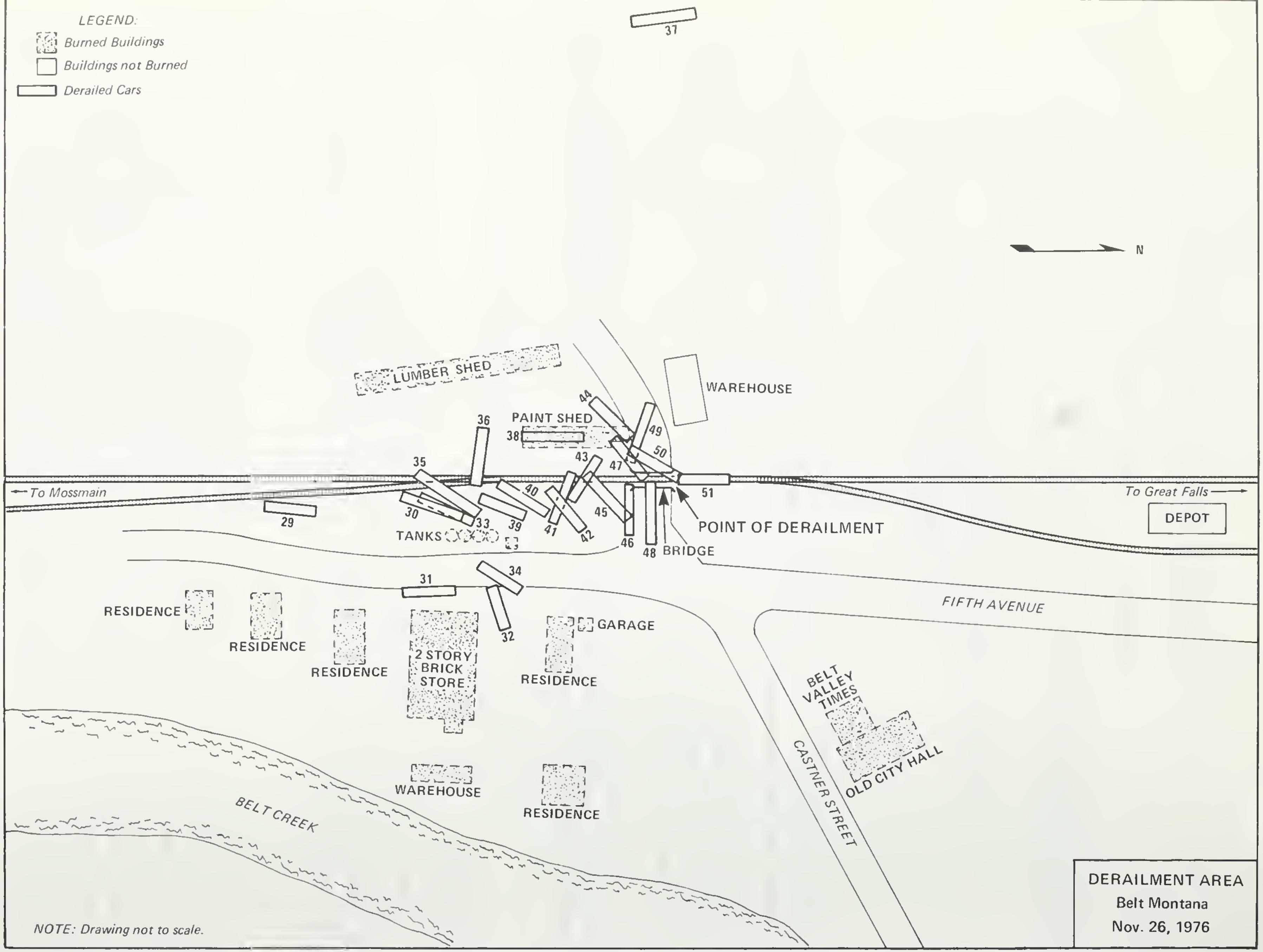

Figure 1. Plan view of accident site.

The initial derailment occurred at the north end of the overpass which carries the single track over Castner Street. The old City Hall building and a newspaper office were about 300 feet northeast of the point of derailment on Castner Street. On the east side of the tracks in the derailment area there were a two-story brick store which belonged to the Farmers Union Cooperative, a warehouse, and several dwellings. In addition, there were four vertical, above-ground, 16,000-gallon tanks for gasoline and fuel oils, two 500-gallon butane tanks, and several small propane tanks. Belt Creek is about 400 feet east of the accident site. A warehouse, a paint storage shed, and a lumber storage shed were on the west side of the tracks. (See figure 1.)

A tank car derailed to the east side of the track where it struck and punctured one 16,000-gallon tank containing gasoline, which was 42 1/2 feet from the track structure. The gasoline immediately ignited. At the same time, the tankhead of the 37th car, a tank car loaded with liquefied petroleum gas (LPG), was punctured. The escaping gas was ignited and the punctured tank immediately rocketed about 400 feet to the west.

Cars No. 40, 41, 42, 43, and 45 were tank cars loaded with No. 6 fuel oil. Several of the tanks were punctured in the derailment and fuel oil spilled onto Castner Street under the bridge. The punctures were made by impacts between the tanks and various car parts during the derailments. The oil ignited and began to flow down Castner Street toward the center of town.

About 1 1/2 hours later, the 34th car, loaded with LPG, which was ruptured and being impinged by fire, exploded. Several firefighters received minor burns and were knocked down when the tank car ruptured. Parts of this car came to rest near the Farmers Union Cooperative building on the east side of the main track.

One 33-foot piece of the east rail was broken into 13 pieces. The first break was 47 inches north of the bridge and the second break was 11 feet 10 3/4 inches south of the first. (See figure 2.) Wheel battermarks on the receiving ends of the broken pieces indicated a number of wheels passed over the breaks before the rail was displaced and allowed the cars to derail. The rail was manufactured by the Bethlehem Steel Company in 1909 and was first laid in a track in 1911. It was installed at Belt about 3 years before the accident.

The track was constructed of 90-pound, 33-foot-long rails of various origins and ages which exceeded 50 years. The rails were connected with 4-hole, 24-inch joint bars. Each rail had 12 rail anchors. Each rail rested on 7 1/2-inch by 10 1/2-inch, single-shoulder tie plates which were laid on twenty 7-inch by 9-inch by 8 1/2-foot crossties per rail length. The rail was secured by two track spikes per tie plate. The track was ballasted with crushed stone.

During the week prior to the accident, a track gang had "smoothed up" the track in the area, which included raising the east rail between the bridge and the switch south of it.

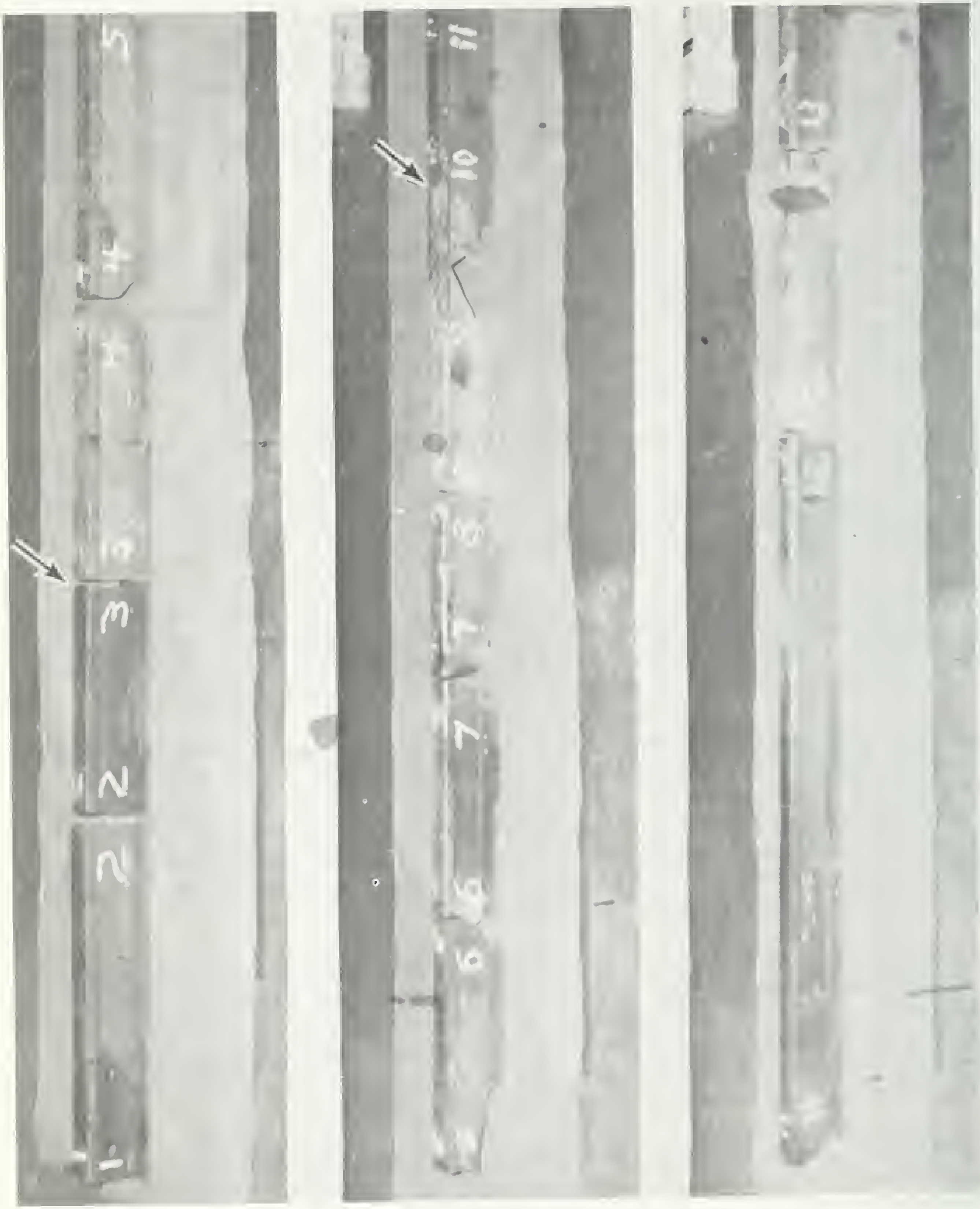

Figure 2. Broken sections of 33-foot rail. Arrow indicates point of initial failure.

A track inspector riding a Hy-Rail car had inspected the track in the area earlier in the day and found no defects. The track had been inspected by a magnetic rail defect detector car on July 29, 1976, and by an ultrasonic defect detector car on August 4, 1976. During these inspections several other rails manufactured in 1909, which were near the bridge, were found to contain internal defects. No defects were found in the east rail at the bridge.

BN requires inspection of the track by a track inspector or a track foreman three times per week. This exceeds the requirement of the Federal regulation which requires only one track inspection per week for Class 3 track. Searches for internal rail defects are not required because no passenger trains operate on this line.

A southbound train approaching Belt moves around a 2° curve to the right for 960 feet and then moves on straight track for 1,066 feet to the point of the derailment and for 1,593 feet farther south. There is a 0.60 percent descending grade for about 5 miles approaching Belt. Dynamic braking is usually employed descending into Belt. The north end of the bridge carrying the single track over Castner Street in Belt is located 495 feet south of the station. Sidings are located along the main track north and south of the bridge.

Injuries to Persons

Injuries	Crewmembers	Passengers	Other
Fatal	0	0	2 missing
Nonfatal	0	0	22
None	6	0	

Damage

Sixteen of the 24 derailed cars were destroyed and the others were heavily damaged. About 270 feet of track and two switches were destroyed and the bridge was damaged.

Five houses were destroyed and several others were damaged. Several commercial buildings, including the Farmers Union Cooperative's entire bulk fuel storage plant, were destroyed. That plant consisted of a general store, garage, warehouse, four vertical, above-ground, 16,000-gallon tanks, two 500-gallon butane tanks, and several small propane tanks. Two of the large tanks contained gasoline, one contained heating oil, and one contained diesel oil. The lumber storage shed and paint warehouse along the west side of the track were destroyed. The newspaper building and the old City Hall in the center of town were destroyed by fire. Nineteen motor vehicles were destroyed and several were damaged.

Highway access to the west and south of the accident site was hampered because Castner Street was blocked by derailed cars and fire. Telephone communications in the area were interrupted for several hours.

Damage-related costs were estimated as follows:

Equipment	$ 500,000
Track	40,000
Property	$4,000,000
Total	$4,540,000

Train Information

The 34th, 37th, and 51st cars of the train were tank cars loaded with LPG, and were not equipped with head shields. The cars complied with U.S. Department of Transportation (DOT) specifications for the transport of this liquid. The 34th and 37th cars were provided with F-type couplers, and the 51st had a standard E-type coupler. The 41st, 42nd, 43rd, and 45th cars were tank cars loaded with fuel oil.

The locomotive consisted of five units with the following specifications:

Type	Weight (Pounds)	Axles
U-33-C	363,600	6
SD-45	368,000	6
GP-30	362,700	4
GP-38	250,000	4
GS-9	249,000	4

Method of Operation

Trains are operated in this territory by timetable and train orders. The maximum authorized speed is 40 mph. Normal daily traffic consists of one freight train in each direction. No passenger trains operate over this line.

Meteorological Information

At the time of the accident the temperature was about 13° F, and in the following 8 hours it dropped to 8° F. The sky was cloudy with a northwest wind of about 20 mph. About 4 inches of snow was on the ground.

Fire

Fire erupted immediately after a tank car collided with the trackside fuel storage tank. Fifty-foot-high flames enveloped derailed cars and buildings within a 300,000-square-foot area around the tank in less than 2 seconds. In a rolling motion the fire advanced eastward toward Belt Creek and spread out to the north and south. Several explosions occurred as the fire burned the derailed cars and nearby buildings. The fires burned for over 12 hours. (See figure 3.)

Figure 3. Aerial view looking south.

The Belt Fire Department quickly responded and directed its attention to the fire advancing on Castner Street toward the town. The old City Hall and a newspaper building were on fire when the fire department arrived. Fire equipment from other localities arrived and the Great Falls National Guard Fire Chief took charge. Trucks dumped earth on Castner Street to dike the fuel oil fire. The dike diverted the oil into Belt Creek, which became contaminated. Disaster planning for assisting in a catastrophe of this nature had not been made with neighboring fire department. However, by 3:15 p.m. 12 fire departments within 30 miles of Belt were responding.

The train crewmembers first unsuccessfully attempted to contact the nearest railroad dispatcher by radio and by telephone. The conductor then instructed the crew to move the remainder of the train southward and place it on a siding.

Initially none of the non-railroad emergency service personnel were informed of the hazardous commodities on the train nor of the location of the waybills. The railroad crewmembers left the scene about 3:15 p.m., and left the waybills in the caboose. The conductor notified a dispatcher of the accident about 3:20 p.m., and made arrangements to move the rear portion of the train to Great Falls. This was the first information that the BN had received about the derailment. When the firechief requested the waybills and information from the railroad dispatcher, he was told that the caboose and undamaged cars had been removed to Great Falls.

About 4:30 p.m., a sound like gas venting to the atmosphere was heard in the main fire area but firemen were unable to determine whether it was from a tank car or one of the propane tanks near the Cooperative's buildings. At 5:30 p.m., a tank car ruptured and a 1,000-foot-diameter fireball spread over the town. At least 10 firemen were within 200 feet of the tank car, but only one firefighter was injured. Parts of the tank were blown 500 feet away.

The hazardous materials on the train were not identified until about midnight when BN officials arrived at the scene with information about the train's cargo.

Survival Aspects

Because of the low outside temperature most residents along Fifth Avenue were indoors at the time of the derailment.

The initial blast damaged the door of a garage on the Cooperative's premises, exposing its eight occupants to a 4- to 6-foot wall of flame. Two of the occupants did not escape with the other six by a rear exit and are missing.

Flames engulfed a house just north of the Cooperative within 10 seconds after its occupants fled.

Tests and Research

The 13 pieces of the broken rail which initiated the derailment were analyzed at the BN laboratory at St. Paul, Minnesota. The chemical composition of the steel

conformed closely to American Railway Engineering Association specifications except for slight deviations above maximum carbon and phosphorus content. The failed sections exhibited classic transverse fissures which had progressed from inclusions in the railhead. The inclusions extended throughout the lengths of the failed section of rail. The transverse fissure at the initial break did not exhibit the sudden or rapid growth rings normally associated with those transverse fissures which exhibit those types of growth. (See figures 4 and 5 and appendix A.)

According to the State Fire Marshall's office the four oil storage tanks, the two 500-gallon butane tanks, and an electric pump used for bulk transfer complied with the Uniform Fire Code. Each of the storage tanks contained an 8-inch escapement for explosive venting with a weak seam weld in the roof. The four vertical tanks were enclosed by a 3-foot-high, 6-inch-thick reinforced concrete firewall.

The tankhead of the 37th car, which was punctured in the derailment, was recovered near a storage tank. An examination disclosed that the puncture was near the top of the head, approximately 12 inches above the horizontal center line. Because of the nature of the puncture it could not be determined definitely what effect a Federal Railroad Administration (FRA)-designed head shield would have had.

Other Information

The Federal Track Safety Standards, 49 CFR 213.237, require that a continuous search for internal defects be made of all jointed and welded rails in Classes 4 through 6 at least once a year. Such inspection is to be made in Class 3 track only when passenger trains operate on it.

ANALYSIS

The battermarks on the fractured surfaces of the broken rail indicate that the rail broke under the wheels of the passing train and that a few wheels passed over the two breaks before the rail was displaced and allowed the cars to derail. If the rail had been broken before the train began to move over it, the locomotive and first 28 cars would have battered the ends of the fractured rail to a much greater degree. Furthermore, the track inspector probably would have discovered the break during his inspection earlier in the day.

As soon as the rail separated and allowed the 29th car to derail, the deceleration of the first cars to derail and those immediately behind them--both from the emergency braking and the deceleration of the derailed wheels--initiated the buckling of the train and the random derailment and dynamics of the following cars. Since the track was on a fill, there was nothing to keep the derailed cars in line and on the roadbed. Consequently, the momentum of the rear cars still on track caused derailment to both sides of the track and random excursions of the cars.

Figure 4. Cross-section of rail section showing nucleus of initial failure.

Figure 5. Cross-section of failed rail showing transverse fissure.

For each 10 pounds of rail section, a rail should support a maximum load of about 3,000 pounds per wheel. 2/ The locomotive of Extra 5734 East, like most others used today, placed loads on the rail in excess of 30,000 pounds per wheel, which is about 3,000 pounds per wheel or 11 percent more than what the 90-pound section should carry. The development of transverse fissures is related in part to heavy wheel loads through dynamic forces. 3/ It is not known to what extent the additional loads from dynamic braking of the heavy locomotive contributed to the failure of the rail.

The chemical composition and type of steel and the amount of rail flexing are factors which must be considered. The imperfect support of the rail, particularly where the roadbed met the bridge abutment, allowed constant flexing of the rail. The low temperature might have been a factor in the fracture of the steel.

Considering that this rail had been in service 25 years before the "control-cooled" rail manufacturing process was adopted by American steel mills, it was predictable that fissures would develop and grow rapidly to critical size. The detection of a number of internal defects in other similar 90-pound rails in the area before the accident also should have indicated to the BN that service failure of this rail was probable.

The number and appearance of the transverse fissures in the broken rail suggest that at least some of them should have been detectable when the detector tests were made in July and August. The inclusion in the head of the rail should have been detectable also. BN should review the capability of its rail flaw detection testing, its quality control, and the analysis of its findings. A review of the history of this 90-pound rail, its overstressing by heavy wheel loads, and the tendency of such rail to develop transverse fissures under such service suggest that the rail should have been removed from mainline service.

Federal Track Safety Standards, 49 CFR 213.237, Inspection of Rail, did not require BN to make an annual "continuous search for internal defects" in the rail at Belt. However, BN tested the rail inductively and ultrasonically 4 months before the accident without a positive indication that internal defects (transverse defects or inclusions) were present. Those inspections would have complied with 49 CFR 213.237(a) and (b) for any class of track, but the inspections did not detect the internal defect from which the failure originated.

This accident suggests that the regulations for inspection of rail should be more specific in their requirements. They should consider the many variables which affect the development and growth of internal defects. These variables include, but are not restricted to, chemical composition of the rail; the type, age, and the service life of the rail; the condition of the roadbed and resultant rail

2/ William G. Raymond, et al., Elements of Railroad Engineering, (New York: Wiley, 1942).

3/ Dr. William W. Hay, "Track Structures for Heavy Wheel Loads," 12th Annual Railroad Engineering Conference Proceedings: Effect of Heavy Axle Loads on Track, Federal Railroad Administration, October 1975.

flexing; and the size and frequency of wheel loads relative to the size of the rail section. The interval of test should consider the past frequency of defect development.

Federal regulations do not require the testing of Class 3 track for rail defects unless passenger trains use the track. This accident suggests that the criteria for testing for internal defects should include not only the class of track but also the class of service to which the track is subjected. In this case the tests in July and August would have complied with Federal regulations even though they did not detect the inclusions and any fissure which might have been there.

In the confusion and fire which followed the derailment, firefighters were unable to determine what the tank cars contained. There was no evidence of an effective BN emergency procedure to notify firefighters of the descriptions and locations of the hazardous materials in the train.

The BN dispatcher learned of the derailment 2 hours before the 5:30 p.m. tank car explosion, and more than 8 hours before the contents of the 11 hazardous materials cars were identified to the firemen. However, he was not able to tell the firechief what was involved because he did not have that information when he first spoke with the firechief about the accident. During a subsequent communication, the dispatcher advised firemen that Christmas trees were involved. The Safety Board, following its investigation of an accident at Glen Ellyn, Illinois, in May 1976, recommended that the Department of Transportation (DOT):

> "Require by regulation that persons performing train dispatching functions maintain a record of trains and cars that are carrying hazardous materials and of current methods of, and procedures for, containment of these materials in the event of a mishap and communicate this information to public safety officials immediately after they learn of a train accident."

Even though the Belt fire department had no formal procedure for marshalling assistance in such emergencies, it cannot be concluded that it adversely affected the outcome of the operation. When the initial derailed car ruptured the gasoline tank, the subsequent ignition of the gasoline and the rapid spread of the fire was inevitable. The response of the neighboring fire departments was as rapid and as effective as could be expected, given the disruption of the telephone service.

The two presumed fatalities are attributed to the gasoline fire that resulted from the impact of a tank car with a gasoline storage tank. The massive property damage resulted from the gasoline fire and the ignition of the LPG that leaked from the 37th car. The presence of other flammable products on the train sustained the fires for approximately 12 hours.

Five persons were burned when the 37th car was punctured near the top of a tankhead, and escaping LPG ignited. The explosion of the 34th car during the fire also increased injury and damages. However, it was not possible to determine whether head shields and shelf couplers could have changed the outcome of the accident because of the variety of damage to the tank cars. Protective head shields and insulation to reduce such losses have been addressed by new regulations issued by the DOT's Materials Transportation Bureau on September 9, 1977.

CONCLUSIONS

Findings

1. The defective rail broke under movement of train Extra 5743 East.

2. The 90-pound rail was subjected to more weight than was contemplated in its original design.

3. The rail failure originated in a transverse fissure.

4. The detector car inspection of the rail on July 29, and on August 4, 1976, did not detect the inclusion or any internal defects in the rail at that time.

5. Burlington Northern's track inspection practice exceeded requirements of Federal regulations for Class 3 track that is not used by a passenger train; however, a detectable defect initiated the derailment.

6. The lack of knowledge of the hazardous materials on the train placed the emergency forces in jeopardy.

7. The absence of a documented cooperative emergency arrangement between the Belt fire department and the neighboring fire departments did not significantly affect the final outcome of the catastrophe.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of an overloaded rail section which originated in an undetected transverse fissure.

RECOMMENDATIONS

As a result of this investigation the National Transportation Safety Board made the following recommendations:

. . . . .to the Federal Railroad Administration:

> "Revise 49 CFR 213.237, Inspection of Rail, to insure the discovery of internal defects in all tracks, Classes 3 to 6, inclusive, before those defects develop into failures. (Class II, Priority Followup) (R-77-29)"

. . . . .to the Burlington Northern:

> "Evaluate the capability of its internal rail defect testing program and make the necessary changes to insure that internal defects are detected before they develop to the failure stage. (Class II, Priority Followup) (Class II, Priority Followup) (R-77-30)

> "Relegate rail section of 100 pounds or less, made of noncontrol-cooled steel, to locations where service failures will not result in catastrophic derailments. (Class II, Priority Followup) (R-77-31)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

September 29, 1977

APPENDIX A

BURLINGTON NORTHERN INC.
OFFICE OF ENGINEER OF TESTS

Upon Future Reference
Kindly Refer to Report Number

GENERAL TEST REPORT NO. 595-76

ST. PAUL, MINN. December 18, 1976

SAMPLE Failed Rail - Derailment, Belt, MT.

FROM ---- SPECIFICATION NO. ----

G.S.K. REGN. NO ---- P.A. ORDER NO. ----

SENT IN BY Mr. J. Bone, St. Paul TEST REQUEST NO. ----

Mr. B. G. Anderson:
Attn. R. G. Brohough:

In reference to verbal conversation with Mr. J. Bone, the Laboratory received and examined the failed 90-lb rail involved in derailment at Belt, Montana.

Attached Photograph No. 13276 exhibits the failed sections.
Identification - Bethlehem 1909

Initial failure occurred at Section 3 on Photograph No. 13276 from a transverse fissure which had progressed from inclusions in rail head. Attached Photograph No. 13276A exhibits nucleus of initial failure. Leading batter on subsequent sections confirms nucleus. It was evident this rail length had inclusions throughout as noted at Sections 2 and 10. Attached Photograph No. 13276 B exhibits the transverse fissure which had also progressed at Section 10.

Chemical Analysis of Rail		AREA SPECIFICATION		
	Failed Rail	81-90#	91-/120#	121#-over
Carbon - %	0.83	.64-.77	.67-.80	.69-.82
Manganese - %	0.82	.60-.90	.70-1.00	.70-1.00
Sulfhur - % max.	0.023	.05	.05	.05
Phosphorus - % max.	0.051	.04	.04	.04
Silicon - %	0.133	.10-.125	10-.25	10-.25

Rail conforms closely to specification, except for slight deviation above maximum carbon and phosphorus content.

Inclusions were produced in rail at manufacture and,whenever present, it is common to be found throughout rail length or lengths of same heat. However, due to service life, failure cannot be considered a manufacturer's defect.

Rail will be held at Como Laboratory pending your disposition.

/s/ Dole H. Propp
ENGINEER OF TESTS

File: 020.11

cc: R.E. Taylor
J. A. Bichsel

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PHOTOGRAPH

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